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ACTA RADIOLOGICA
EDITA IUSSU SOCIETATUM RADIOLOGICARUM
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VOL. 43 APRIL 1955 FASC. 4

THE MEDIASTINAL PLEURA

by

Folke Knutsson

The descriptive and topographic accounts which appear in textbooks of anatomy are based on observations made on cadavers, and are set out in minute detail in the belief that they correspond to conditions during life. Roentgen diagnostics have, however, often necessitated a re-assessment. The wealth of descriptive matter loses its practical significance to the extent that the anatomy in cadaver is unrepresentative of the living state. The textbooks of anatomy are ripe for partial reorientation, the irrelevant details being limited and the discrepancies between the state on cadavers and the conditions during life stressed.

The mediastinal pleura. According to the textbooks of anatomy, the costo-vertebral pleura joins the mediastinal pleura along the straight line of the lateral borders of the vertebral bodies. The posterior mediastinum is accordingly described as a wide space traversed on the anterior surface of the vertebral bodies by the aorta and oesophagus (Fig. 1).

POIRIER, however, describes sinus-like incursions of the mediastinal pleura into the mediastinum and gives an account of bilateral retro- and ante-oesophageal pouches. The most constant and important of these is found on the right side between the oesophagus and the vertebral column ('cul-de-sac pleural interazygo-œsophagien'), and this is represented by a corresponding structure on the left side between the oesophagus and the aorta ('cul-de-sac interaortico-œsophagien'). POIRIER states that these two recess formations at the level of Th. 9 closely approximate. He has found them to originate from the arch of the aorta and the attachment of the azygos vein respectively, continuing downwards to the diaphragm, and separated only by a thin layer of tissue (inter-pleural ligament). LACHMAN has reported these recess formations also in the upper part of the mediastinum. According to POIRIER, the ante-oesophageal recess formations are insignificant, and are limited to the space between the oesophagus and the pericardium within a triangular region measuring

Submitted for publication, 2 December 1954.

From the Roentgen Departement (Director: Professor FOLKE KNUTSSON), University Hospital, Upsala, Sweden.

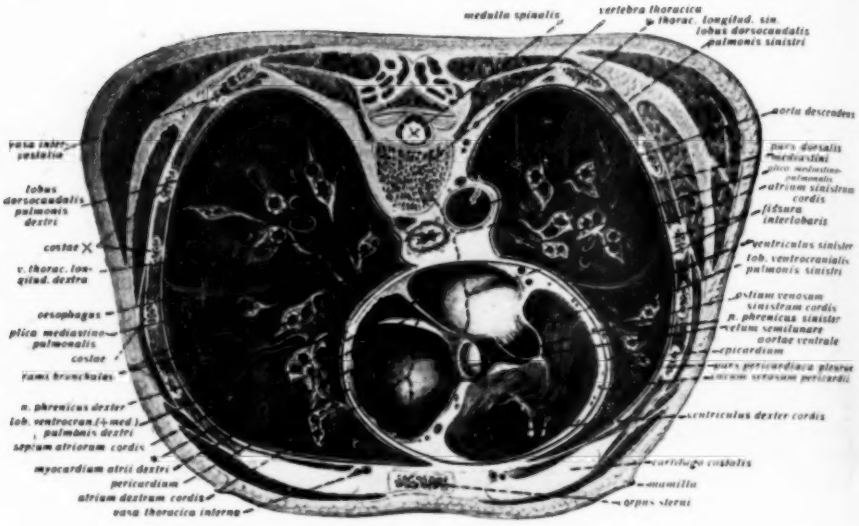

Fig. 1 (After SOBOTTA). Transverse section of the thorax from a cadaver. The posterior mediastinum consists of a short wide space, the oesophagus lying close to the vertebral column.

only 2 to 3 cm in height and with its base on the diaphragm ('culs-de-sac préœsophagiens').

HEISS has carried out detailed studies of the posterior mediastinum by means of a special dissection technique, the pleural cavities being filled with plaster-of-Paris. The line of junction between the vertebral and mediastinal portions of the left pleura was found to be practically straight and situated over the lateral borders of the vertebral bodies. On the other hand, he found that the right pleura, between Th. 5 and Th. 10, forms an extensive recess, bulging into the mediastinum and extending beyond the mid-line, the distance between the two pleurae being thus reduced to about 1 cm (Figs. 2 and 3).

HAFFERL makes only brief mention of a bilateral retro-oesophageal recess, which he calls 'recessus mediastino-vertebralis'. DANELIUS has demonstrated in cadavers that the posterior mediastinal pleura from the apex downwards arches inwards towards the mid-line. At the level of Th. 4 and Th. 5, the two pleurae may actually be in contact (Fig. 4). GLADNIKOFF, by means of roentgen examinations of living subjects has confirmed this, and has established that the oesophagus lies interposed between folds of pleura with which it is directly invested. He has also proved that in the living subject the line of junction between the ver-

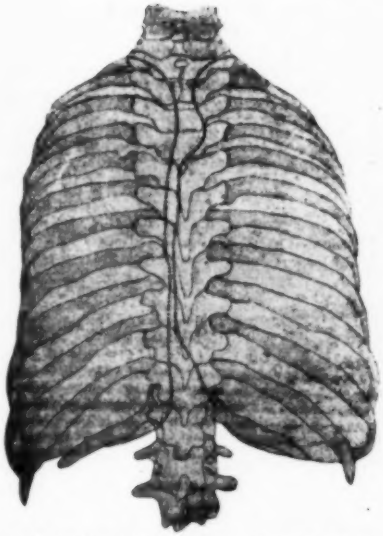

Fig. 2 (After HEISS). The left mediastinal pleura starts at the lateral border of the vertebral body. On the right, the mediastinal pleura makes a deep antevertebral incursion into the mediastinum.

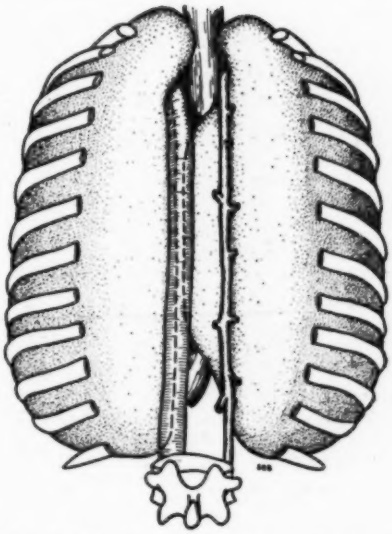

FIG. 3 (After LACHMAN). Diagrammatic representation of HEISS's dissection.

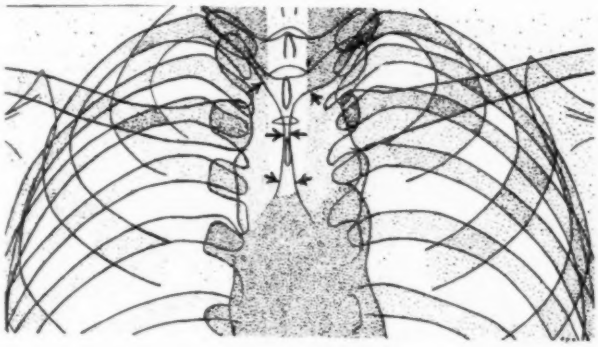

Fig. 4 (After DANELIUS). The superior part of the posterior mediastinum is extremely narrow owing to the deep pleural incursions on both sides.

tebral and mediastinal pleurae corresponds to the anatomic findings of HEISS.

EDLING has stressed the importance of analysing the pleural contours in the posterior mediastinum and along the lateral borders of the

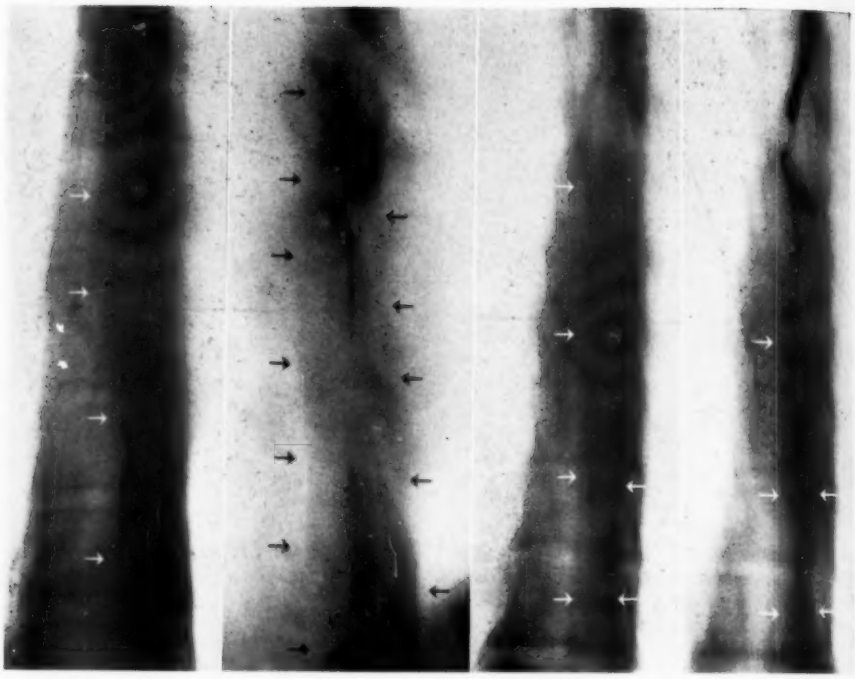

Fig. 5. Frontal tomography of the posterior mediastinum reveals that this is far narrower than in cadavers, the mediastinum is displaced to the left, the right pleura makes an antevertebral incursion into the mediastinum towards the midline, and that the left pleura follows the lateral borders of the vertebral bodies. (Traces of contrast medium in the oesophagus.)

vertebral bodies in diagnosing pathologic changes in the pleura itself and in the adjacent parenchyma lung tissue. BILLING has worked out the appearance of the paravertebral pleural contours in various radiologic projections.

The occurrence of pleural recesses in the posterior mediastinum has thus been established in anatomic studies in cadavers. It has been possible to study their incidence, volume, and depth, in the living individual subject only to a limited extent by means of conventional roentgenography. In tomography we now have a method by which we may obtain sections of the living body, making comparisons between the topographic conditions in the living subject and the cadaver possible.

Frontal tomography of the posterior mediastinum reveals that its width within the region from the bifurcation of the trachea downwards

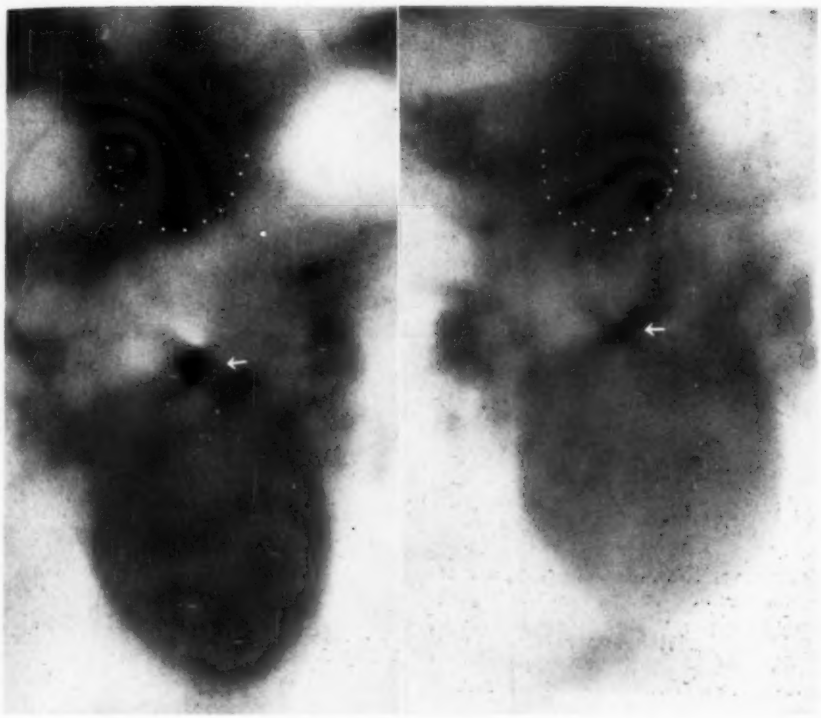

Fig. 6. Transverse tomography at the level of the hilum. (Traces of contrast medium in the oesophagus.)

is considerably less than would appear from the anatomic descriptions; this width may amount to less than 2 cm. The mediastinum is not situated about the mid-line but slightly to the left. On the left side, the mediastinal pleura starts from the lateral surface of the vertebral bodies but, on the right side, the vertebral part of the pleura continues on the anterior surface of the vertebral bodies to approximately the mid-line where it becomes the mediastinal pleura (Fig. 5).

Transversal tomography at about the level of the hilum demonstrates the comparatively great distance between the vertebral bodies and the oesophagus, the latter being in contact with the heart. This distance varies from case to case. In these tomograms the space between the vertebral column and the heart appears relatively uniformly air-filled (Fig. 6). The technical limitations of the process as a rule prevent the narrow mediastinum from being defined as a region of soft tissue shadowing interposed

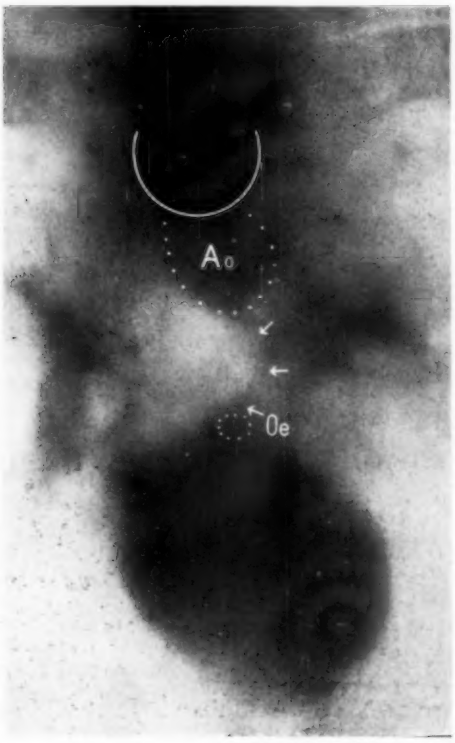

Fig. 7. Transverse tomography at the level of the hilum. Deep incursion of the right pleura into the mediastinum. Ao = aorta, oe = oesophagus.

between the two lungs. Fig. 7, however, demonstrates clearly the right lung bulging over the mid-line between the vertebral column and the oesophagus, indicating that in this case the mediastinum must have been very narrow. This bulge corresponds to the mediastino-vertebral recess. A schematic comparison between the morbid and living anatomy is made in Fig. 8.

Costo-mediastinal sinus. The junction between the right mediastinal and costal pleurae on the whole follows the border of the sternum, but on the left side it forms a convex bulge laterally, at the level of the 5th and 6th costal cartilages. Great individual variations, however, occur, the lines of junction being displaced either to the right or to the left.

Similarly, the course of the anterior border of the lung varies from one individual to another, that is to say, the area of absolute cardiac

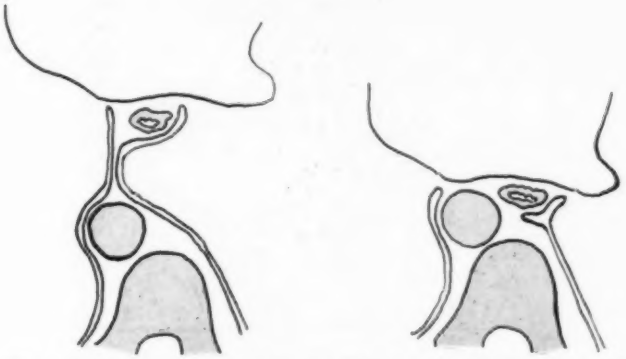

Fig. 8. The posterior mediastinum in the living subject and in the cadaver.

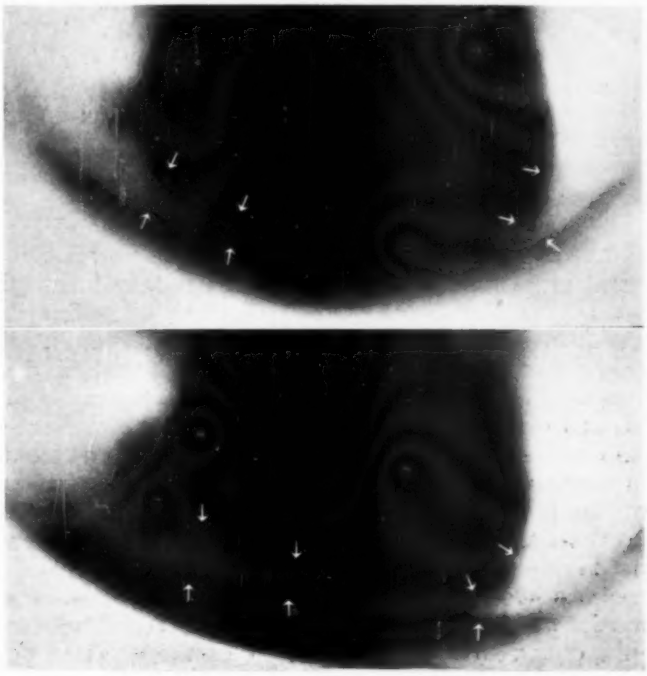

Fig. 9. Transverse tomography of the anterior mediastinum to demonstrate the position of the anterior pulmonary borders and the uncovered area of the heart (the area of absolute cardiac dullness).

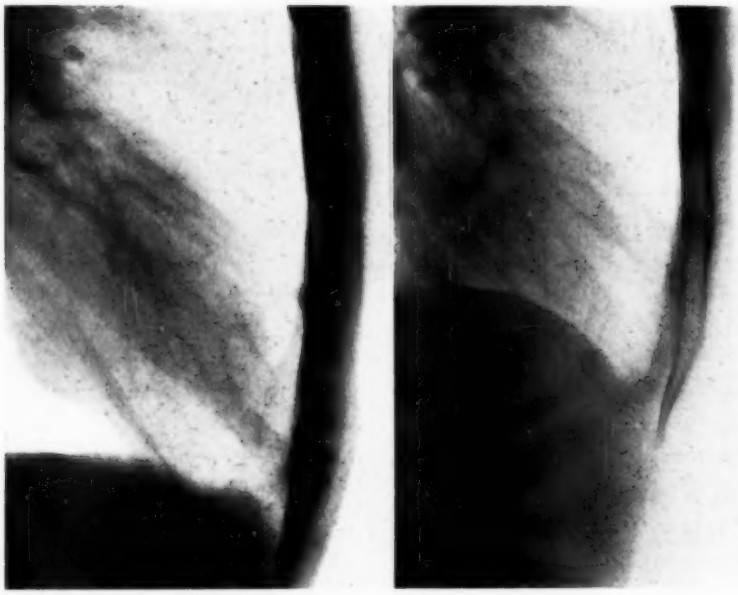

Fig. 10. Lateral views of the chest in inspiration and expiration. The air-filled lung tissue bears the same contact with the sternum in both situations.

dullness is not constant. These anatomic divergences are not apparent in the frontal projection, but, on the other hand, influence the lateral view.

The transversal tomogram of the anterior mediastinum at the level of the heart shows to what extent the anterior border of the lung approaches the mid-line, as well as the displacements which occur during inspiration and expiration (Fig. 9). A representation of the anatomic basis for the area of absolute cardiac dullness may thus be obtained. In making an assessment of the influence which the position of the anterior borders of the lungs has on the lateral projection, the anterior mediastinum has been examined during both inspiration and expiration. The variations have been considerable. In some cases, the air-filled lung parenchyma was in contact with the sternum to the same extent during both inspiration and expiration (Fig. 10); in others, a retrosternal shadow, which could only represent that portion of the anterior part of the heart not covered by lung tissue, was narrower during inspiration, and wider and different in shape during expiration (Fig. 11). This discrepancy may clearly be ascribed to the varying positions of the anterior pulmonary borders. Thus, it is sometimes possible to determine radio-

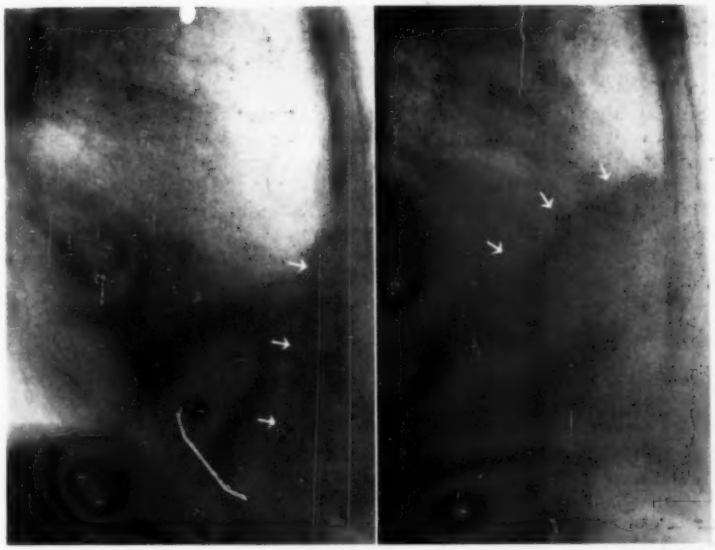

Fig. 11. A retrosternal soft tissue mass changes in shape and width on inspiration and expiration; this is explained by a change in position of the anterior pulmonary borders.

logically whether a retrosternal shadow is due to a pathologic pleural adhesion or whether it is the radiologic representation of the area of absolute cardiac dullness.

With the aid of the traditional radiologic technique supplemented by tomography, it is thus possible to map out the living anatomy and to establish certain differences between it and the state on cadavers. Knowledge of the normal radiologic anatomy is clearly an essential requirement for differentiating the pathologic from the non-pathologic. It is, for example, of fundamental importance to be familiar with the normal course of the mediastinal pleura in diagnosing pathologic herniations. That the right lung bulges into a mediastino-vertebral recess anterior to the vertebral column results in difficulties in projecting any parenchymatous changes in this region free from the vertebral column; such changes may thus be overlooked.

In assessing changes in the anterior mediastinum it may be helpful to compare films taken during inspiration and expiration. In this way, the effect of the position of the anterior pulmonary borders on the lateral view of the thorax may be ascertained, since retrosternal shadowing may be the radiologic representation of the area of absolute cardiac dullness and consequently of no pathologic significance.

SUMMARY

The living anatomy of the posterior mediastinum may be mapped out by means of frontal and transversal tomograms, comparison with the anatomy on cadavers thus being made possible. During life, the posterior mediastinum is considerably narrower than would appear from cadavers, and is situated slightly to the left of the mid-line. The right pleura makes a deep antevertebral incursion into the mediastinum.

In certain cases, a retrosternal shadow seen in the lateral view will change in width and shape on respiration, suggesting that it depends on the varying position of the anterior pulmonary borders in the costo-mediastinal sinus.

ZUSAMMENFASSUNG

Die Anatomie am Lebenden kann für das hintere Mediastinum durch frontale und transversale Tomogramme dargelegt werden; auf diese Weise ist ein Vergleich mit der Anatomie an Leichnamen möglich gemacht worden. Beim Lebenden ist das hintere Mediastinum beträchtlich enger als es von Studien an Leichnamen zu erwarten wäre; weiterhin ist es etwas links von der Mittellinie gelegen. Die rechte Pleura macht eine tiefe antevertebralen Einbuchtung in das Mediastinum.

In gewissen Fällen ändert ein von der Seite her sichtbarer retrosternaler Schatten bei der Atmung sowohl Breite wie Form; dieses deutet an, dass der Schatten auf der variierenden Stellung der vorderen Lungengrenzen im Sinus costo-mediastinalis beruht.

RÉSUMÉ

L'anatomie sur le vivant du médiastin postérieur peut être représentée grâce à des tomographies frontales et transversales, ce qui rend possible la comparaison avec l'anatomie chez le cadavre. Pendant la vie, le médiastin postérieur est considérablement plus étroit qu'il ne paraît sur le cadavre; et il est situé un peu à gauche de la ligne médiane. La plèvre droite fait une profonde incursion prévertébrale dans le médiastin.

Dans certains cas, une ombre rétrosternale visible sur la radiographie de profil change de largeur et de forme avec la respiration, ce qui fait penser que ces changements dépendent de la position variable des bords antérieurs des poumons dans les sinus costo-médiastinaux.

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ROENTGENDENSOMETRIC RECORDING OF HEPATIC AND PORTAL CIRCULATION[1]

by

Gunnar Tornvall and *Björn Nordenström*

Studies of the liver circulation in the intact animal or in man have hitherto been hampered by technical difficulties, largely by reason of the inaccessibility of the portal vein. Certain earlier experiments may be mentioned.

An indirect method has been described whereby the circulation time from the rectum to the lungs is measured; ether is instilled into the rectum of the patient and the time taken for it to reach his breath noted (10). The pressure at which the mucous membrane in the sigmoid becomes pale after insufflation of air has been measured; this affords information concerning the flow of blood in the portal vein. Attempts have also been made to draw conclusions concerning the circulation in the portal system from measurements of the pressure in dilated collateral veins on the abdomen of patients with cirrhosis of the liver (4). Again, it has been shown that certain kinds of sugar and albuminous substances, administered orally, appear earlier, and in greater concentration, in dilated abdominal veins than in the cubital vein (1, 2, 3 and 14).

The liver circulation has been studied in rabbits with radioactively labelled substances (15). If $Na^{24}Cl$, or red blood corpuscles tagged with P^{32}, are injected through a catheter inserted in the thoracic aorta of a rabbit, the passage of the labelled substances may be recorded by means of a Geiger-Müller tube. Curves with two maxima are then obtained. By occluding the portal vein and the hepatic artery, respectively, evidence has been gained to support the opinion that one maximum is caused by the passage of the labelled substances through the hepatic artery

[1] This investigation was supported by the James Picker Foundation, on recommendation of the Committee on Radiology, National Research Council.

Submitted for publication, 12 December, 1954.

and the other by its passage through the portal vein. It was difficult with this method, to carry out repeated recordings. For this reason, another method of studying the liver circulation was tried, and is now described. It is connected with a previously indicated roentgen-densometric method for the study of the circulation time through the lesser circulation (11). With the aid of a photocell, the time is recorded for the reduced roentgen ray transmission occurring when a contrast embolus passes between the photocell and the source of radiation. The method was elaborated in experiments in 16 dogs of different breeds, weighing between 9 and 30 kg.

Heart catheters, size 10, were used for injection of the contrast medium. A pneumatic injection syringe, which allowed constant injection pressure to be maintained, was employed. By means of contacts on the syringe, an interfering voltage was introduced in series with an electrocardiograph circuit at the beginning and end of the injection. A step-shaped interference, marking the beginning and end of the injection, was thus obtained on the electrocardiogram. The passage of the contrast medium through the liver was recorded with a direct-recording electrokymograph (Elema, Stockholm), fitted with two photocells. One of these was placed in the primary beam of the roentgen source, and the other over the liver. By anti-phase coupling of the currents of the photocells, most of the interference in the densogram, arising from the pulsating intensity variations of the roentgen source, was eliminated. In view of the relatively high ray-absorption of the liver, the aperture of the photocell, which was placed over the liver, was increased to 10 × 25 mm, while the dimensions otherwise are 6 × 25 mm.

The roentgen radiation was supplied by a standard 6-valve apparatus. The densograms were recorded at 3 mA and 80 to 90 kV. The control densogram of a masonite phantom, corresponding to the opacity of the liver in the dog, showed that the level of the densogram curve was constant for at least 3 minutes. (For more detailed information on the pneumatic injection syringe, reference may be made to the above-mentioned earlier publication (11).)

Sodium acetriozate was used as the contrast medium and in some experiments a 70 % concentration of iodopyracet. Heparin (Vitrum) was employed as an anti-coagulant. To avoid respiratory variations in the densograms it was necessary to stop the animals' breathing movements before the contrast injections were given. This was effected by the injection of succinylbischolinediiodide (Celocurin, Vitrum) and the simultaneous intratracheal administration of oxygen.

The general condition of the animals was controlled by means of the electrocardiogram, and, in some cases, by continuous recording of the arterial blood pressure. The latter was directly recorded in a brachial

artery with transmission of liquid to a direct-recording mercury manometer on a rotating kymograph paper.

The animals were anaesthetized with pentobarbital sodium (Nembutal — Abbot) injected intraperitoneally in amounts of 0.5 ml/kg body weight. In most of the cases ether on open mask was also given during the experiments. The dogs were then placed on a trochoscope table in the supine position and turned slightly to the right. The heart catheter was introduced into the aorta via one of the femoral arteries, with its tip at the level of Th. 9 to 12. Heparin was administered through the catheter in amounts of 1 to 1.5 mg/kg body weight to prevent coagulation.

A thick, short cannula was introduced into the brachial artery on one side and connected to the mercury manometer of the kymograph. Oxygen was supplied intratracheally while the breathing movements were stopped by injection of celocurin in amounts of 1 to 1.5 mg/kg body weight.

When the blood pressure became level, the photocell was placed over the right lobe of the liver, 2 to 3 cm from its right margin, under fluoroscopic control. A densogram of the liver was then taken to ensure that no respiratory disturbances were occurring.

During continuous control of the densogram and the electrocardiogram (lead II), the contrast medium was injected into the aorta against the bloodstream. The amounts of contrast usually were 2 to 3 ml per injection.

The densogram curve

When the contrast medium was injected into the aorta, densogram curves of the type shown in Fig. 1 were obtained. The curves had the following characteristics: 1) immediately following the injection a rapid rise in the curve to a maximum of short duration occurred; 2) after a slight lowering of the curve level, another, considerably longer maximum followed; 3) the return to the level prior to the injection was remarkably slow.

Analysis of the maxima of the densogram curve. In order to determine the cause of the two maxima, the hepatic artery and the portal vein, alternately, were temporarily occluded in four experiments.

To enable the hepatic artery or the portal vein to be occluded, a loose thread loop was placed round each of these vessels after laparotomy. The threads were then drawn through slightly bent glass tubes. By pulling the threads the mouth of the glass tubes could be pressed against the vessels. An occlusion of the hepatic artery or the portal vein was in this way easily achieved.

Occlusions of the hepatic artery and portal vein have been made

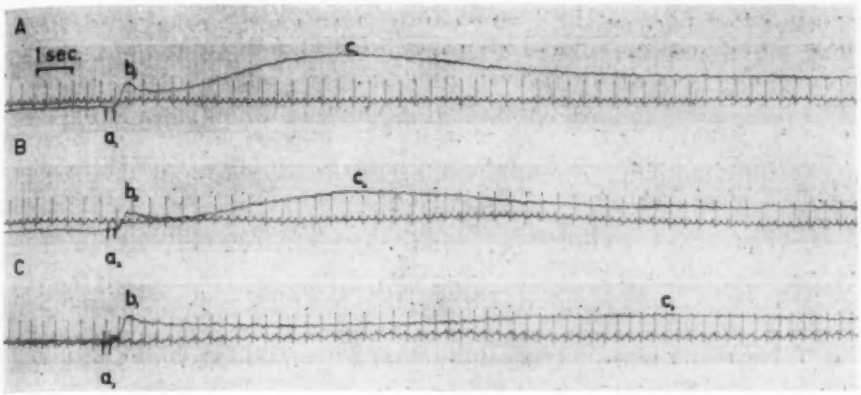

Fig. 1. A. Typical densogram curve. The beginning and end of the injection (a) in the aorta are indicated on the electrocardiogram. The densogram curve contains first a short maximum (b) and then a longer one (c). After maximum No. 2 the level of the curve sinks with remarkable slowness. Curve B. New densogram from the same animal, 5 minutes later. Curve C, obtained in an experiment in another animal, has a considerably longer interval between the maxima than curves A and B.

previously in studies of the liver circulation (6, 9, 12). A temporary interruption in the portal flow will give a considerable temporary fall in blood pressure in the systemic circulation, while more pronounced changes in blood pressure do not arise on occlusion of the hepatic artery. This was also the case in our experiments. Circulatory balance cannot thus be guaranteed when the portal vein is occluded; in spite of this, it was considered reasonable to make use of the occlusion method for a rough analysis of the construction of the densogram.

The upper curve in Fig. 2 shows the change in the densogram, observed after the injection of contrast medium into the aorta during obstruction of the circulation through the portal vein. In the experiments, the second, slow rise in the curve did not occur, but the first rapid rise persisted. This first rise is therefore most probably caused by the circulation of the contrast medium through the hepatic artery.

The lower curve in Fig. 2 shows the change in the densogram curve after occlusion of the hepatic artery. In these cases, the first rapid rise is eliminated, while the second slow one is retained. The second densogram maximum may thus be assumed as chiefly due to the passage of the contrast medium through the portal vein. As shown by the figure, the assumed portal component will occur before the hepatic artery component entirely stops. Theoretically, a shift to the left of the portal maximum can occur as a result of the summation. This shift increases as the slope

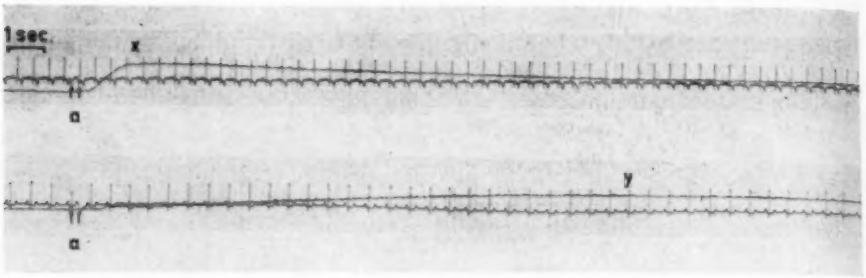

Fig. 2. Upper curve: Densogram after occlusion of the portal vein. The curve has one maximum. This represents the first maximum in the composite densogram curve (see Fig. 1) and should be due to the passage of the medium through the hepatic artery. Lower curve: Densogram after occlusion of the hepatic artery. Only the maximum corresponding to the second one of the composite curve now remains (see Fig. 1). This may therefore be reasonably assumed to be caused by the passage of the medium through the portal circulation.

in the descending part of the hepatic artery component becomes more pronounced. The hepatic artery curves which were, however, obtained when the portal vein was occluded, showed a rapid falling off of the descending part of the curve, so that it is improbable that the hepatic artery component can have any significant effect on the time of occurrence of the total maximum.

Analysis of the slow return of the densogram curve. The densogram curve never returned completely to its bottom level after the portal response, although recording was continued in most cases for several minutes. It was thought that retention of contrast medium in the liver could be the reason for this; the iodine content of the liver at different times after the injection was therefore determined in a special series of experiments. Rabbits were used instead of dogs. A control of the densogram was carried out beforehand to show that the densogram curve was in principle the same as for the dog.

The abdomen of the anaesthetized animals was opened by an incision in the midline. A thin polythene catheter was inserted into the abdominal aorta after both the iliac arteries had been ligated. The tip of the catheter was advanced up to the level of the lower thoracic vertebrae and the contrast medium injected rapidly into the aorta. At different intervals, the liver together with the spleen were rapidly excised. The total content of contrast medium in these organs was determined by the following method.

Each organ was dissected with a propeller knife (Turmix). After repeated extractions with distilled water, the latter was carefully evaporated in a water bath. The iodine content of the substance remaining was then

Table 1

Rabbit	Roentgen contrast (70 % sodium acetrizoate) amount injected cc	Organ removed after minutes	Liver			Spleen			Notes
Number Weight g			weight g	Iodine mg	Iodine mg per g of liver	weight g	Iodine mg	Iodine mg per g of spleen	
I 1.650	0.5 = 230.3 mg Iodine	0.5	73.6	15.1	0.205	0.431			Double analysis.
II 1.600	0.5 = 230.3 mg Iodine	1.0	76.0	11.8	0.155	0.556	0.18	0.319	
III 2.050	0.5 = 230.3 mg Iodine	2.0	107.3	18.8	0.174	0.861			
IV 1.620	0.5 = 230.3 mg Iodine	5.0	75.8	5.3	0.069	0.855			
V 1.900	0.5 = 230.3 mg Iodine	10.0	65.1	3.6	0.055	0.761			Double analysis.
VI 1.850	5.0 = 2.303 mg Iodine	1.0	66.2	75.7	1.043	0.685	1.00	1.459	Double analysis. Cramps after injection.
VII 1.800	—	—	64.6	0.99	0.015	0.791			Double analysis. Control animal.

determined after alkaline oxidative combustion by titration with sodium thiosulphate. (The chemical analyses were carried out by the Astra Laboratory.) The results of these experiments are given in Table 1.

This table shows that the amount of iodine found in the liver of the animals which had received contrast medium is higher than in the control animal No. VII. The organs removed after the injection of contrast medium show a lower iodine content than those removed earlier, with the exception of rabbit No. III, which, however, differed from the others also on account of its considerably greater weight. The largest amount of contrast medium in the liver was obtained in rabbit No. VI, which was given 10 times as much as the others. The analysis values indicate presence of the medium in the liver which may explain the rise in the densogram curve and its slow return.

The iodine content in the spleen of animals Nos. II and VI was also determined. The values obtained show a clearly higher iodine concentration in that organ than in the liver.

Additional observations. After occlusion of the portal vein or the hepatic artery it was in some cases impossible to regain the original curve

with two maxima on removal of the occlusion. This may have been due to spasms in the vessels caused by drawing the threads around them. Transillumination experiments have previously shown that there are sphincters within the terminal branches of the hepatic artery and portal vein, which can contract independently of one another (7). In operative intervention in rats and cats, cramp has moreover been noted in the peripheral vessels of the liver. By means of angiography, it has been demonstrated that the contrast medium in some cases passes through all the vessels of the liver, while in others it passes only through the central vessels (5). A shunting of the blood flow in the liver in conjunction with the operative intervention may also possibly explain why two maxima cannot always be regained on the densogram curve when the occlusion is removed.

When contrast medium injections were given without operative intervention on the abdomen, good agreement was obtained between repeated injections, as may be observed in Fig. 1 A and B. In longer experiments, when the animal's circulation deteriorated, a delay and a falling-off of the portal maximum of the curve could be observed (see Fig. 1 C).

It appears from these experiments that in the study of the liver circulation, operative intervention on the portal and hepatic vessels may significantly upset the circulatory relation between these two vascular systems.

Discussion

The greatest difficulty in these experiments was to avoid respiratory distortions of the densograms. This factor must be controlled in some way. In these experiments, which were performed exclusively in animals, it has hitherto been simplest to stop the breathing by means of celocurin during the simultaneous intratracheal administration of oxygen; a direct influence on the circulation is thereby exerted. In spite of this, it was possible to notice alterations in the relation between the hepatic and portal components.

Different vascular reactions occurring when roentgen contrast media are used for intravascular injections have previously been described. Immediately after the injections, vascular constriction was observed, followed by vascular dilatation (8). Such vascular reactions, if more pronounced, may of course influence the circulation time. Relatively small amounts of contrast medium were used in these experiments. No changes, or only insignificant ones, were usually observed in the arterial blood pressure. The procedure introduced was primarily intended to provide possibilities for the rough estimation of the relation between the

hepatic and portal circulation. In investigations in the same animal at constant blood pressure it was moreover possible to obtain concordant densogram curves.

The experiments have also indicated means of calculating the hepatic and portal circulation times by this method. This may be done as follows. The middle of the injection time, obtained from the interference points of the electrocardiogram, is taken as the starting point. The hepatic response maximum is used as the reference point for the circulation through the hepatic artery and the portal response maximum for the portal circulation.

SUMMARY

A method for recording the liver circulation after the injection of small amounts of contrast medium in the thoracic aorta of the dog is described. A roentgen source was placed under the animal, and the reduced intensity of radiation which occurred when the medium passed through the liver, was recorded electrokymographically. A curve with two maxima was thus obtained, the first showing the response to the circulation in the hepatic artery, the other being caused by the circulation in the portal circuit. The possibility of obtaining an expression for the circulation time in the hepatic artery and in the portal circulation is discussed.

ZUSAMMENFASSUNG

Eine Methode für die Registrierung der Leberzirkulation nach Injektion kleiner Mengen eines Kontrastmittels in die Aorta thoracica des Hundes wird beschrieben. Eine Röntgenstrahlenquelle wurde unterhalb des Tieres aufgestellt und die reduzierte Strahlungsintensität, die beim Passieren des Kontrastmittels durch die Leber auftrat, wurde dann elektrokymographisch registriert. Auf diese Weise erhielt man eine Kurve mit 2 Maxima; das erste zeigt die Beeinflussung durch die Zirkulation in der A. hepatica, das zweite ist durch die Zirkulation im Portakreislauf hervorgerufen. Die Möglichkeit, eine Formel für die Zirkulationszeit in der A. hepatica und im Portakreislauf zu finden, wird besprochen.

RÉSUMÉ

Les auteurs décrivent une méthode d'enregistrement de la circulation hépatique après injection de petites quantités de produit de contraste dans l'aorte thoracique du chien. Une source de rayons roentgen est placée sous l'animal et la réduction d'intensité de radiation qui se produit quand le contraste traverse le foie est enregistrée électrokymographiquement. On obtient ainsi une courbe avec deux maxima, le premier correspondant à la circulation dans l'artère hépatique, le second dû à la circulation dans le circuit portal. Les auteurs examinent la possibilité d'obtenir une expression du temps de circulation dans l'artère hépatique et dans la circulation portale.

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FROM THE SURGICAL CLINIC (DIRECTOR: PROFESSOR L. TORRACA) AND THE ROENTGEN DEPARTMENT (DIRECTOR: D. CATALANO), UNIVERSITY OF NAPLES, ITALY.

HEPATOGRAPHY AFTER PERCUTANEOUS LIENO-PORTAL VENOGRAPHY

by

D. Catalano, A. Giardiello and *A. Ruggiero*

The roentgen examination of the liver, other than that portion forming a part of the biliary tract, has been limited until now to conventional roentgenography and the procedure of the pneumoperitoneum or extraperitoneal insufflation of air with or without tomography. By means of these methods it is possible to demonstrate calcifications or translucencies within the liver area and to study the borders of the organ, although, in many cases, it is not possible to obtain satisfactory information concerning the intrinsic pathology. Many efforts, such as the intravenous injection of Thorotrast, have been made in the past to render the liver opaque, but the procedures tried have now almost completely been abandoned by reason of their toxicity or the limited degree of hepatic opacification obtained.

Rigler, Olfelt and Krumbach (7) have recently proposed a new method of performing hepatography by the injection of a contrast medium into the aorta by means of the usual technique for abdominal aortography but employing 40 ml Urokon 70 % and entering the aorta with the needle directed upwards at the level of the eleventh thoracic vertebra. The films are obtained when the contrast medium injected reaches the liver through the hepatic artery and later at the time of its venous return from the various abdominal organs. This procedure, although of considerable interest, does not appear to be suitable in every case. Moreover, the degree of opacity obtained seems to be less than that possible with other procedures, including our own.

Roentgen studies of the venous liver circulation, particularly of the portal vein, have been made in the last few years by the introduction of a contrast medium, after laparotomy, through one of the tributaries or sub-tributaries of the portal vein, preferably the right gastro-epiploic

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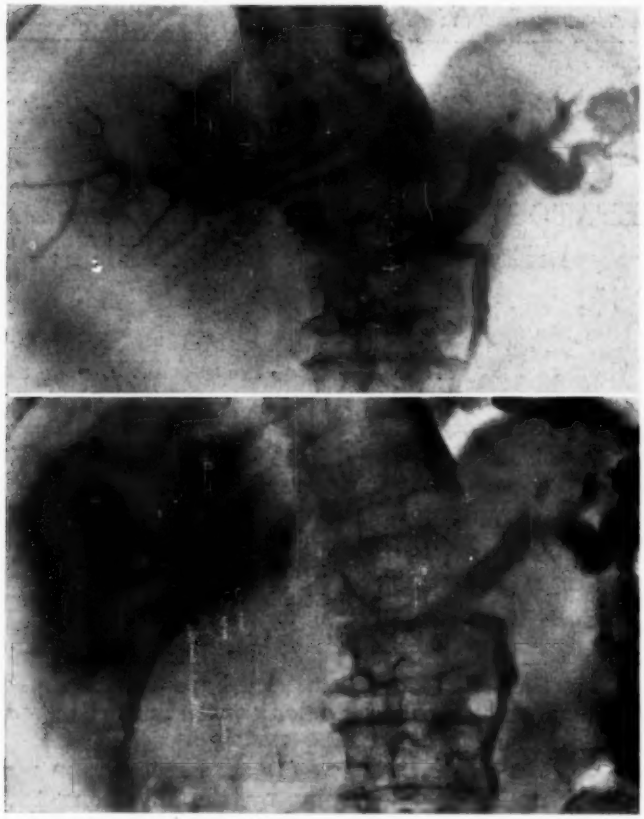

Fig. 1. Metastasis in the left lobe of the liver. Lienal phlebography. a. The major branches of the portal vein. b. Homogeneous opacification of the liver except the left lobe.

vein (5, 6, 8), or directly into the portal vein by the percutaneous transhepatic technique (9).

We (2, 3), as well as others (1, 4), have succeeded in introducing a contrast medium into the portal vein by the transparietal intrasplenic route. Our technique and results in splenic, pancreatic and portal pathology have been reported elsewhere (2, 3). The procedure has resulted in a satisfactory degree of opacification of the liver. The contrast medium injected into the splenic parenchyma passes through the splenic and portal veins into the liver. The films obtained therefore first show intrahepatic branches of the portal vein outlined, followed by diffuse opacification of the liver.

Fig. 2. Cyst of the liver. a. The major branches of the portal vein are dislocated from the cyst. b. No opacification of the cyst.

We consider that vascular hepatography is a good procedure to follow and among the numerous forms of vascular injection of the contrast medium, the splenic route is superior to all the others. It is relatively easy to perform and apparently without danger.

It will be appreciated that opacification of the liver cannot be achieved with the splenic procedure in cases of splenic or portal venous obstruction; splenic venography will then be indicated for demonstrating the cause and site of the obstruction and the possible collateral circulation.

Figs. 1 a and b show the two principal phases of hepatic visualization: firstly the major branches of the portal vein were outlined, followed by the diffuse and homogeneous opacification of the liver. In this case there was a metastatic tumour mass within the left lobe of the liver; the tumour area was not rendered opaque. LEGER and co-workers (4) have reported a similar finding in a case of a hepatic metastasis.

In a case of cyst of the liver, hepatography (Fig. 2) demonstrates clearly that the area occupied by the cyst was avascular and that there was compression and distortion of the major branches of the portal vein

ZUSAMMENFASSUNG

Die Verfasser richten die Aufmerksamkeit auf die Opazität der Leber, die nach einer lienalen Phlebographie auftritt und welche von diagnostischem Wert sein kann.

SUMMARY

The authors draw attention to the opacification of the liver which occurs after lienal phlebography and which can be of diagnostic value.

RÉSUMÉ

Les auteurs attirent l'attention sur l'opacification du foie qui suit la phlébographie splénique et qui peut avoir un intérêt diagnostique.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: PROFESSOR P. FLEMMING MØLLER),
UNIVERSITY HOSPITAL, COPENHAGEN, DENMARK

PNEUMORETROPERITONEUM IN SUPRARENAL DISEASE

by

Poul E. Andersen

The diagnosis of suprarenal diseases has always been difficult radiologically. Essential progress, however, has been made during the last few years by the use of aortography and the introduction of 'the pneumoretroperitoneum' or 'extraperitoneal pneumography', and the present report is an attempt to evaluate this method in the diagnosis of diseases of the suprarenal glands.

Pneumo-retroperitoneum (p. r. p.) is the term generally used to describe the diagnostic method in which a gas, usually oxygen, carbon dioxide, or air, is injected into the loose extraperitoneal areolar tissue to act as a contrast medium to the viscera which it surrounds.

The principle of the method is not new. CARELLI and co-workers, and ROSENSTEIN, 1921, injected carbon dioxide by the lumbar route into the renal and suprarenal space as a contrast medium, and CAHILL, 1935, reported the demonstration of hypertrophy and tumours of the adrenals by this means. Accidents, however, as reported by WEYRAUCH and MENCHER, brought discredit to the method.

In 1947, RUIZ RIVA introduced the present method by using the precoccygeal and presacral route for establishing a diffuse and extensive emphysema around the posterior abdominal viscera; by this means, these were better outlined than by previous method. This first report was followed by several others, especially from Latin countries, in which the value of the method in urologic diseases and a few cases of suprarenal tumours was pointed out. A major report was published in 1952 by DE GENNES, MAY & HÉLIE, who, however, had operative verification in only five cases of suprarenal disease. The present report has operative verification in twelve cases and contains the largest published material examined by p. r. p.

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Technique. The anatomy of the extraperitoneal loose areolar tissue and the technique of gas insufflation have been extensively described by RUIZ RIVA, DE GENNES et coll., FAGERBERG, STEINBACH et coll. and other investigators. However, as our technique is simple and easily reproduced, its main points may be of interest. The equipment consists of two 2-litre bottles, connected by a siphon system, a source of oxygen with a manometer, and the necessary amount of rubber tubing. Before the p. r. p., one bottle is filled from the oxygen source while the other is filled with water; during the p. r. p. the water is forced from the latter to the former, so that the oxygen passes through a rubber tube and injection needle into the presacral space, the two bottles functioning as a sort of buffer system and at the same time measuring the amount of oxygen injected. The rubber plugs of the bottles also function as safety valves so that if anything should happen to the oxygen source, any increased pressure will not be transmitted to the patient. Oxygen has been used because it is easily available, for example on any anaesthetic machine; its absorption rate is sufficiently slow to allow diffusion through all the necessary extraperitoneal spaces; and because it produces a satisfactory roentgen examination which, if necessary, may be extended over several hours. Further, oxygen is said to have only a limited tendency to cause serious embolism should a vein be pierced during the injection (FAGERBERG; STEINBACH et coll.), an accident which we, however, have never encountered.

The patient is given a mild sedative or anodyne in the ward, $^1/_2$ to 1 hour before the p. r. p. The examination and its possible inconveniences are explained to the patient in the roentgen department. He is then placed in the knee-elbow or the left lateral decubitus position, and the injection site just anterior to the tip of the coccyx is prepared with iodine; no local anaesthetic is necessary. The needle is inserted through the skin and the subcutaneous tissue until the tip meets the anococcygeal raphe. The index finger of the free (usually left) hand is placed in the rectum to verify the position and direction of the needle which is then inserted another 2 to 4 cm with the point as far posterior as possible to avoid perforation of the rectum. After the position of the tip of the needle in the loose retro-rectal tissue has been verified, we make sure that no blood vessels have been punctured. The injection apparatus is now attached to the needle through rubber tubing with a cotton filter, and the oxygen is injected at a rate of 150 to 200 ml per minute, the rate varying with the size of the patient, the amount of fatty tissue, and the patient's reaction to discomfort in the flanks and the abdomen. A total amount of about 1,500 ml is generally employed. When the needle has been withdrawn, the patient is placed first in the erect position for a few minutes, then in the right lateral decubitus position, and finally in the left lateral decubitus position for 5 to 6 minutes; the diffusion of oxygen into the right renal space usually requires more time than into the left space. Fluoroscopic control has been abandoned as being usually superfluous. Four standard roentgenograms are then obtained with the patient in the prone, the supine, the left oblique, and the right oblique positions, to evaluate the p. r. p. and as a preliminary or control examination before special roentgenograms and tomograms are made. Usually only frontal tomograms have been obtained, but no doubt sagittal — as advocated by VESPIGNANI — and transverse tomograms should have been used more extensively; they may yield very useful information. In one of our cases sagittal tomograms might have provided the correct diagnosis, a suprarenal adenoma not being visible on the frontal tomograms and the suprarenal gland consequently considered normal.

Complications. No fatal accidents have been reported so far and only a few serious complications, such as gaseous embolism (DE GENNES, MAY & HÉLIE; RUSS, GLENN & GIANTURCO). In the present series, no serious complications occurred, and only a few inconveniences to the patients have been encountered.

In one patient suffering from a large scrotal hernia, the loose tissue of the scrotum became filled with oxygen during the p. r. p., the size of the scrotum reaching almost that of a cocoanut before what had happened was realized. Moderate pressure and the placing of the patient in the erect position corrected the condition in a few minutes. Similar cases have been reported by, among others, DE GENNES et coll.

Mediastinal emphysema at the conclusion of the examination has been a very common finding, seen in well over 50 per cent of all cases in the final routine control roentgenogram of the thorax, but in no instance giving rise to symptoms. Although not intended, in several cases we obtained excellent demarcation of the heart, great vessels and thymus, thus demonstrating the applicability of the pneumomediastinum by the retroperitoneal route as proposed by BACCAGLINI in 1949.

In two cases, the gas passed into the areolar tissue of the neck, causing cervical emphysema. One of these patients had a slight sensation in the throat without respiratory difficulty, while the other patient had no symptoms, the cervical emphysema being an accidental roentgen finding; there was typical crepitation upon palpation. Similar cases have been reported by BENHAMOU, VIALLET & CHEVROT, and DE GENNES, MAY & HÉLIE, also without serious sequelae.

Free air in the peritoneal cavity, *i. e.* pneumoperitoneum, was observed in one patient at the conclusion of the examination which had been carried out without incident. A rupture of the peritoneum must have occurred but the patient had no special symptoms, and no reaction was observed later.

Thus, so far, no serious complications have been met with, and this coupled with the ease with which the examination may be performed makes the method most suitable for the radiodiagnostic of adrenal diseases.

Material. During the period 1951—1953, pneumoretroperitoneum was carried out in 48 patients with manifest or suspected suprarenal disease, with a total of 54 p. r. p. Exploratory or radical operations were performed in 12 patients, in 4 cases bilaterally. During the same period, several cases of hypertension of suspected renal origin were examined as were numerous cases of other renal diseases. Of course the suprarenal glands were also examined in these cases, but as the main interest was directed towards the kidneys and no definite abnormalities of the adrenals were found, the investigation sometimes being insufficient on one side, these patients have not been included in this material.

The reasons for the investigation by p. r. p. may be summarized as follows. In 8 cases a Cushing's syndrome was the preliminary diagnosis, while 2 cases strongly suggested pheochromocytoma and 16 cases, adrenocortical hyperplasia. In 6 cases, the main cause was hypertension which

was suspected to be of suprarenal origin, while the remaining 16 patients suffered from various other pathologic conditions, in most of them marked adiposity or amenorrhea being the reason for the examination.

Radiologic Findings. The value of the p. r. p. as a diagnostic method in cases suspected of suprarenal disease has to be judged by considering not only those cases in which an operative verification (or non-verification) exists, but those in which operation was not performed for various reasons. It must at once be emphasized that the evaluation of the roentgenograms demands considerable experience and may be difficult, especially as regards size of the gland in cases of suspected hyperplasia with marked clinical hyperfunction. The so-called 'normal' appearances are variable and may include:

a) Sharply demarcated triangular shadows, the right often smaller than the left, which may be more or less comma-shaped with a prolongation downwards towards the renal hilum. In the sagittal tomograms, the left suprarenal gland is often smaller from before backwards.

b) Somewhat vaguely demarcated, homogeneous triangular shadows, the medial and superior-lateral borders of which are fairly well distinguishable, while the inferior border may be completely or almost completely confluent with the renal shadow, the borders as a whole often blurred by the reticulation of the surrounding fatty tissue (VESPIGNANI).

c) Vaguely demarcated, non-homogeneous shadows of varying size in the suprarenal spaces and on the medial surface of the kidneys, sometimes vertically streaked or granular. This form is called 'lipo-parenchymatous' by the French authors.

While the diagnosis of an enlarged suprarenal gland of the first type may be fairly easy, one should be considerably more reserved in cases of the 'lipo-parenchymatous' variety, even if at times a correlation between a large shadow and biologic hyperfunction apparently exists.

As mentioned, 12 patients had one or more operations on the suprarenal glands and this group is by far the most important in estimating the diagnostic value of the p. r. p. In most cases the pre-operative clinical diagnosis was the same as the final diagnosis, but in some the operation had to be an exploratory one on one side on account of the conflicting clinical findings. More important, however, than the final agreement between the preoperative diagnosis and the findings at operation, is the accordance between the radiologic diagnosis and its confirmation on surgical intervention, as this decides the practical value of the method in daily routine work. The result of the p. r. p. was in conformity with the findings at operation in 9 out of 12 cases, including one case of pheochromocytoma in which no filling of the renal-suprarenal space could be obtained in spite of repeated p. r. p. with varied positions, manipulations, etc.

Table 1

Size of suprarenal glands in 35 non-operated cases

Suprarenal glands		Normal	Enlarged	Possibly enlarged
Urinary hormone excretion increased		9	3	3
Urinary hormone excretion normal		16	3	1
	Total	25	6	4

Three cases which show a discrepancy between the results of the roentgen examination and the findings at operation thus remain. In the conventional films supplemented by frontal tomograms, suprarenal glands of normal shape and size were evident in one of these cases. This was confirmed in the bilateral operation which followed, but in the lower hindmost part of the right suprarenal gland a small mass was felt, but at that time was considered to be in the nature of a hemorrhage into the gland. Biopsy, however, revealed pronounced hyperplasia with adenoma formation. In this case, sagittal tomography might perhaps have revealed the condition; it undoubtedly should be used to a larger extent than is customary — as advocated by VESPIGNANI. In another case the right gland seemed to be somewhat enlarged. At operation, the right suprarenal gland, in the surgeon's opinion, "was free from hyperplasia or growth"; biopsy, however, showed changes in the cortex which was presumed to be slightly hyperplastic. In the third case, the suprarenal glands were found to be of equal size and hardly enlarged radiologically. The surgeon found a considerably enlarged left suprarenal gland, almost twice the normal size, while the right gland was smaller than the left and not hyperplastic. Biopsy showed a slightly hyperplastic cortical zone of the left suprarenal gland. Revision of the roentgenograms (the four standard projections and frontal tomograms) did not reveal any definite enlargement of the left suprarenal gland, but, again, in this case sagittal tomograms might have aided the demonstration of the enlargement.

Considerable conformity between the radiologic and surgical findings has thus been found in these 12 cases. The remaining 36 cases, in which no surgical exploration was performed, naturally are of less value as no objective control of the radiologic findings was possible. Clinically, they form a most inhomogeneous group. One patient was suspected of Addison's disease. The p. r. p. showed suprarenal shadows of normal size and shape; biochemical investigations finally also disproved the preliminary diagnosis. The remaining 35 patients may be placed in two groups (Table 1): a) cases in which thorough, clinical (especially hormonal) investigations invalidated the suggestion of suprarenal disease (hyperplasia or tumour), and b) cases in which increased urinary excretion of one or more hormones was demonstrated, the total clinical condition of

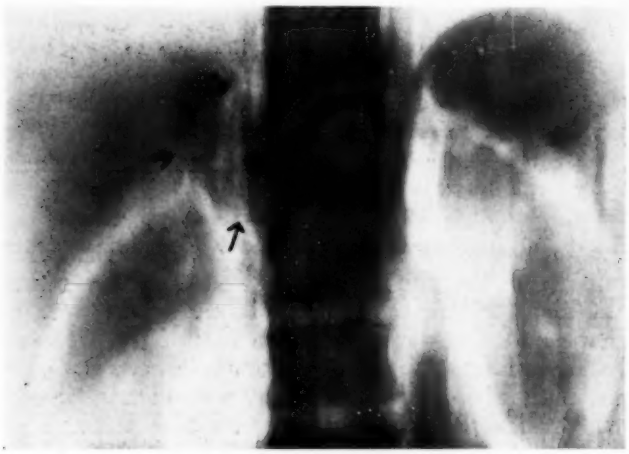

Fig. 1. Tomography. Enlarged right suprarenal gland due to a pheochromocytoma weighing 17.5 g.

the patient, however, not justifying surgical intervention. In 25 cases, the p. r. p. showed suprarenal shadows of normal size and shape while, in 6 cases, the suprarenal gland on one or both sides was considered larger than normal; 4 were border-line cases. Thus, of a total of 25 cases of biologic hyperfunction of the adrenals, only 9 cases showed roentgenographic evidence of enlargement of the suprarenal glands. This is in conformity with the findings of DE GENNES, MAY & HÉLIE, who emphasized the dissociation of biologic and radiologic signs in suprarenal hyperfunction. On the other hand, we would stress that of 9 operated cases of hyperfunction only 2 were found to be quite normal at p. r. p. and operation while one was open to discussion. As cases operated upon are usually those with the most marked clinical signs, it seems justified in maintaining that with advancing severity in the clinical condition there is an increased chance of finding enlarged suprarenal glands. The decision whether a suprarenal glandular shadow is enlarged may be extremely difficult, and we feel that an attempt should be made to measure the volume of both suprarenal glands in the frontal and sagittal tomograms, and a correlation made with the clinical condition.

Two cases of pheochromocytoma were encountered. In one of these (Fig. 1), a right-sided globular shadow was missed at first, but found on revision, and at operation a tumour weighing 17.5 g was removed. It was lying partly in front of the vertebral column. In the other case, we failed to fill the right renal space in spite of repeated p. r. p. with injection of oxygen to the right of the coccyx and with the patient in

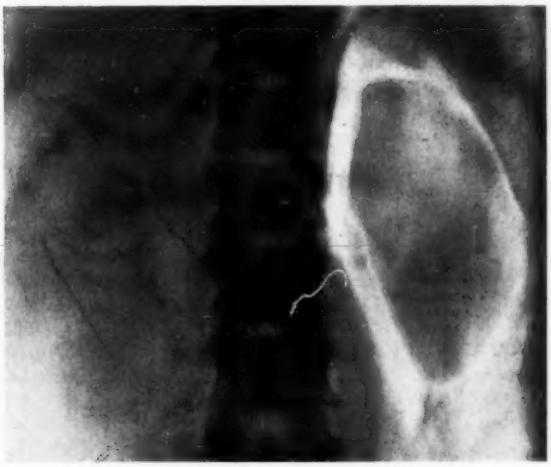

Fig. 2. Tomography. No filling of the right renal-suprarenal space; the p. r. p. was repeated twice with the same result. Normal left kidney and suprarenal gland.

the left lateral decubitus position for a considerable period. At operation, a pheochromocytoma weighing 35 g was removed. The tumour was completely inside the suprarenal gland which merely consisted of a thin surrounding shell. As the history of the patient was completely negative as regards any suggestion of perirenal inflammation, the non-filling of the right renal suprarenal space cannot be satisfactorily explained (Fig. 2). De Gennes, May & Hélie; Hickel and others have found non-filling in cases of perinephritic inflammatory processes but not in cases of clearly demarcated tumours. In the other case of pheochromocytoma, there was no difficulty in producing a satisfactory filling of the renal-suprarenal space.

Conclusions

From the reports in the literature and our own experiences we feel justified in regarding the pneumoretroperitoneum as the best method for the radiologic diagnostic of suprarenal diseases. The investigation is easy to perform, and there are no or only a few complications or untoward effects. The conventional roentgenograms will, as a rule, demonstrate the kidneys and the suprarenal glands, but tomography should be widely used and is often quite indispensable, especially when the so-called lipo-parenchymatous shadows are found. The tomograms should be obtained frontally and sagittally in order to determine the dimensions

(and perhaps volume) of the suprarenals. The evaluation of the size of the gland shadows may be difficult; the dissociation between the radiologic and biologic signs in suprarenal cortical hyperfunction is emphasized, although it seems that a close agreement appears as the severity of the clinical signs increases.

SUMMARY

The diagnostic value of the pneumoretroperitoneum in suprarenal disease based upon 48 cases, 12 of which were subjected to operation, is discussed. The dissociation between the biologic and radiologic findings in cortical hyperfunction is stressed but some relationship between the size of the suprarenal glands and the clinical condition exists as the severity of the clinical increases. The pneumoretroperitoneum is considered a most valuable diagnostic method.

ZUSAMMENFASSUNG

Der diagnostische Wert des Pneumoretroperitoneums bei suprarenalen Erkrankungen wird auf Grund von 48 Fällen, von denen 12 einer Operation unterworfen wurden, besprochen. Der Unterschied zwischen den biologischen und den radiologischen Befunden bei Hyperfunktion der Rinde wird betont, aber gewisse Beziehungen zwischen der Grösse der Nebennierendrüsen und dem klinischen Befund bestehen in der Schwere der klinischen Erscheinungen. Das Pneumoretroperitoneum wird als eine sehr wertvolle diagnostische Methode beurteilt.

RESUMÉ

L'auteur examine la valeur diagnostique du pneumo-rétropéritoine dans les affections surrénaliennes sur 48 cas dont 12 ont été opérés. Il souligne la dissociation entre les signes biologiques et radiologiques dans l'hyperfonctionnement cortical, mais, à mesure que la gravité des signes cliniques augmente, il existe une certaine relation entre le volume des glandes surrénales et le tableau clinique. Le pneumorétropéritoine est considéré comme une méthode diagnostique de très grande valeur.

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FROM RADIUMHEMMET (DIRECTOR: PROFESSOR S. HULTBERG) AND THE INSTITUTE OF RADIOPHYSICS (DIRECTOR: PROFESSOR R. SIEVERT), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

RADIOACTIVE YTTRIUM (Y^{90}) AS A POSSIBLE ADJUNCT IN THE TREATMENT OF PAPILLOMATOSIS OF THE URINARY BLADDER

by

J. Einhorn, L. G. Larsson and *Inger Ragnhult*

Several methods have been introduced during the last years for the treatment of multiple superficial tumours of the urinary bladder with γ-emitting radioactive substances. The urinary bladder has usually been extended to the desired volume by a rubber balloon. In some techniques, a solid radioactive source (radium or Co^{60}) has been positioned centrally in the rubber balloon, and the latter extended by an inactive fluid (6, 9, 12). In other techniques, the rubber balloon has been filled with a radioactive solution (Co^{60}, Na^{24}, Br^{82}) (4, 11, 14, 15) or with a macro-suspension of small Co^{60} pellets (2). Multiple Co^{60} beads have also been inserted directly into the urinary bladder (1).

Successful treatments have been reported with all the methods mentioned. Due to the low radiosensitivity of the tumours, the dosage must be high; this causes rather severe reactions. The penetrating γ-radiation also augurs a considerable risk of fibrotic changes with reduced function of the bladder (4, 12). In our opinion, based on experience, these methods should be reserved for patients in whom the only surgical alternative is radical extirpation of the bladder.

A large number of the tumours in the bladder consist of very superficial papillomas with slender villi. Penetrating γ-radiation is unnecessary in these cases and a sufficient depth dose may be obtained with β-radiation. The β-emitting substance must, however, be in close contact with the mucous membrane, and probably the best method is to insert a radioactive solution directly into the urinary bladder. On the other hand,

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if the solution were to be inserted into a rubber balloon, the presence of but a thin layer of urine between the balloon and the mucous membrane would cause a very irregular surface dose. The direct insertion of the solution has, furthermore, the advantage that papillomatous villi will be completely surrounded by the solution and receive sufficient irradiation.

Before artificial radioactive substances were available, some early trials were carried out with thorium X directly inserted into the bladder (7, 16). Due to the very short range of the α-particles in the tissue, this treatment gave no practical results. Colloidal radioactive gold (Au^{198}) was recently used in this way by ELLIS and OLIVER (7). Au^{198} has a soft β-radiation with an average energy of only 0.35 MeV and is thus useful only for extremely superficial tumours. Encouraging results were nevertheless obtained and demonstrated the possibility of dealing with these tumours by means of a β-method.

An ideal radioactive substance introduced in solution into the bladder for β-irradiation should have the following properties:

1. Energetic β-radiation.
2. No γ-radiation.
3. Should remain in stable solution and not be precipitated by the urine.
4. Should not be resorbed through the mucous membrane.
5. Possess short physical half-life to reduce the risk if accidents occur, or some part is retained in the body. Too short a half-life would, however, in practice, be inconvenient and 2 to 4 days is probably the optimum.
6. Short biologic half-life in the body after intravenous injection in order to reduce further the risk if accidents should occur during the application (venous reflux).

Colloidal Au^{198} fulfils only the third, fourth and fifth of these demands. In the search for an ideal β-emitting isotope for the purpose, our attention was directed to Y^{90}. This isotope has a half-life of 61 hours, a hard β-radiation with a maximal energy of 2.23 MeV, and a mean energy of 0.9 MeV (8). The maximal penetration of its β-rays in soft tissue is about 11 mm. No depth dose curves were available. Sr^{90} decays to Y^{90} with a half-life of 25 years and emits β-particles with a maximal energy of 0.54 MeV. It seems likely that the depth dose from Y^{90} will not be very different from that of Sr^{90} when the soft betas from its first decay have been filtered away. Such depth dose curves reveal a half-value layer of about 1 mm of soft tissue (8).

The direct incitement to our work with Y^{90} was a paper by LEWIN, HART, GREENBERG, SPENCER, STERN and LASZLO (10). These investigators discussed the possibility of using Y^{90}, an energetic pure β-emitter,

for carcinomatosis of the pleura and the peritoneum in place of the commonly employed colloidal Au^{198}. They injected tracer doses of $Y^{90}Cl_3$ into the peritoneal cavity of mice with ascites tumour and of terminal cancer patients. They found that most of the radioisotope remained within the peritoneum if sufficient amounts of carrier yttrium were added to the solution. If the carrier amount was small, a considerable part of the isotope disappeared from the peritoneal cavity and was found in other parts of the body, especially the liver.

The radiotoxicity of Y^{90} following its general administration is incompletely known. BERLIN and LAWRENCE injected doses of about 3 mC at intervals of 4 to 8 weeks in patients with chronic leucemia and observed remissions in the leucocyte counts (3). The distribution of Y^{90} in the body, and consequently its biologic effect, highly depends, however, upon its chemical form. The distribution of Y^{90} after intravenous injection was studied by LEWIN et coll. (10). When $Y^{90}Cl_3$ was injected, most of the radioisotope was taken up by the liver, probably due to the formation of high molecular complexes. If, however, Y^{90} was given with a chelating agent, ethylenediaminetetraacetic acid (EDTA), it behaved principally as a small molecular inorganic electrolyte as regards diffusion and urinary excretion; most of the isotope was excreted in the urine during the first 24 hours and very little was taken up by the liver.

If a radioactive substance must be given with carrier, the toxicity of the latter may be a special problem. Yttrium belongs to the less toxic metals (5). Ten mg of yttrium were injected intravenously in a rabbit without any toxic effects, while 500 mg caused the death of the animal from respiratory paralysis (13). The LD_{50} of yttrium in rats was found to be 132 mg/kg if injected intraperitoneally as YCl_3 (5). Several drops of an 1 per cent solution of yttrium in the human conjunctiva caused only a slight transient irritation (13).

Own investigation

Our two main purposes were to investigate if Y^{90} was absorbed through the mucous membrane of the bladder, and if it was possible to keep it in stable solution during the application.

Y^{90} was delivered from Harwell as Y_2O_3. It was dissolved in dilute HCl with the formation of $Y^{90}Cl_3$ and diluted to the concentration required with physiologic NaCl solution. The resulting solution was strongly acid ($pH < 1.6$). In the presence of urine, a precipitate of yttrium phosphate was formed; this was dissolved only if the mixture was made strongly acid (pH below 2). The problem was apparently to keep yttrium in stable solution during the application and for that purpose we investigated the effect of two chelating agents, Ca-di Na EDTA (Mosatil, Bayer)

and Na citrate. In order to obtain an idea of the necessary amounts of the chelates the following experiments were performed. To 100 ml of a solution containing 100 mg YCl_3 prepared according to the above-mentioned method, different amounts of chelating agent were added (0.4, 0.6, 1.2, 1.8, 2.4 and 3.6 g Ca-di Na EDTA or Na citrate to 0.3, 0.6, 0.75, 1.2, 1.9 and 3.0 per cent). To this solution, 100 or 300 ml of acid or alkaline concentrated urine (pH 5.7 and 7.5, respectively) were added. The solution was examined after three hours for the existence of any precipitate. In Table 1 the lowest concentration of chelate which prevented precipitation, is indicated.

Table 1

Chelate	Acid urine, pH 5.7		Alkaline urine, pH 7.5	
	100 ml	300 ml	100 ml	300 ml
Ca-di Na EDTA	0.6 g	0.6 g	0.6 g	1.8 g
Na citrate	1.2 %	> 1.9 %	3.0 %	> 3.0 %

Both chelates examined could keep YCl_3 in solution. The Ca-di Na EDTA complex was more stable against changes in pH and against an excessive addition of concentrated urine. In the concentrations employed, these agents also changed the pH value of the prepared strongly acid YCl_3 solution to 4—5.

Tracer tests were performed in seven patients to investigate the resorption (or lack of resorption) of Y^{90} through the mucous membrane of the urinary bladder. The intake of fluid was restricted to a minimum during the last 20 hours before the test in order to reduce the flow of urine. A common catheter was inserted into the bladder, the latter emptied, and the catheter obstructed near the external orifice of the urethra. The solution was then injected with a syringe needle through the wall of the catheter. In each experiment, 50 ml of hypotonic NaCl solution containing 0.5 mC $Y^{90}Cl_3$ and 100 mg carrier yttrium (as YCl_3) was injected and followed by 25 ml physiologic NaCl solution injected through the same needle. In the first three experiments, no chelate was added while in the last four, the radioactive solution also contained 3.6 g Ca-di Na EDTA. The duration of the application varied from 1.5 to 2.5 hours. After that time the bladder was emptied and washed out with 700 to 800 ml physiologic NaCl solution. Just before the bladder was emptied a blood test was taken, and the urine was collected for a period of 24 hours after the application.

In the first three experiments, in which no chelate was added, a precipitate of yttrium phosphate was obtained, and the method was thus, for practical purposes, unusable.

In the four experiments in which EDTA was added to the radio-

active solution, no precipitation occurred. In one of the experiments, there was an accidental leakage of solution along the catheter, and the measurement of the activity regained (about 80 per cent) was not quantitative. In the other three tests, a thicker catheter was used and no leakage occurred. In these experiments, about 100 per cent of the amount of Y^{90} injected was regained when the bladder was emptied and washed out. The activity in the blood and in the 24 hours urine was demonstrable but extremely low (Table 2). Probably the risk for resorption through the urinary bladder may be further reduced by the use of some colloidal form of Y^{90}.

Table 2

	Case 5	Case 6	Case 7
Time of application	1 h. 30 m.	1 h. 45 m.	2 h. 15 m.
pH of urine before application		5.3	5.7
Amount of Y^{90} regained in the first portion	88.8 %	79.8 %	89.5 %
Amount of Y^{90} regained in the washing fluid	8.0 %	21.7 %	10.7 %
Total amount of Y^{90} regained	*96.8* %	*101.5* %	*100.2* %
Total amount of Y^{90} in the 24 hours urine after the application	0.11 %	0.04 %	0.08 %
Y^{90} in the blood (at the end of the application)	0.010 % /liter	0.004 % /liter	0.008 % /liter
Volume of the solution at the beginning of the application	75 ml	75 ml	75 ml
Fluid volume emptied	160 ml	200 ml	120 ml

(All the radioactivity measurements were performed with a G.-M. liquid counter of Veall's type. The activity was compared with the activity of a standard solution of Y^{90}, taken from the original solution. The values thus include correction for the physical decay.)

Some practical considerations as regards the dosage calculation need to be added. Due to the flow of urine, the volume of fluid in the bladder will gradually increase. This fact, in addition to the physical decay of Y^{90}, causes a continuous decrease of the dose rate on the surface. It is of course desirable that the irradiation dose should be predicted with some degree of accuracy. If the fluid intake of the patient is restricted during a sufficient time the rate of urinary flow will be about constant and may be determined by repeated evacuation of the bladder before the application. If the mean energy for the β-particles is 0.9 MeV, the

half-life 61 hours, and the specific weight of the fluid about 1.0, the following equations are obtained.

$$R_0 = 960 \cdot \frac{A}{a}$$

$$R_t = 960 \cdot \frac{A \cdot e^{-0.011\ t.}}{a + ut}$$

rate of urinary flow, u ml/hour; application time, t hours; inserted volume, a ml; inserted activity, A mC;

surface dose rate at the beginning of the application,	R_0 rad/h
» » » » » end » » »	R_t »
average surface dose rate	R_m »
total surface dose	D rad.

The application time will in practice be short compared with the half-life Y^{90} and the following approximation may be used:

$$R_m = \frac{R_0 + R_t}{2}$$

$$D = t \cdot R_m$$

A practical example will demonstrate the size of the activity which will be necessary. If the rate of urinary flow is 25 ml/hour and 25 mC Y^{90} is introduced in the bladder in a volume of 75 ml, the surface dose after three hours will be about 700 rads. In order to avoid too high activities and too long application time multiple treatments will probably be necessary.

SUMMARY

The wanted properties of a β-emitting radioactive solution which may be directly introduced into the urinary bladder for the treatment of superficial papillomatosis are discussed. The authors demonstrate that $Y^{90}Cl_3$ with carrier yttrium and a chelating agent (EDTA) could be kept in stable solution with only negligible absorption through the normal urinary bladder.

ZUSAMMENFASSUNG

Die Eigenschaften, welche eine betastrahlende radioaktive Lösung haben muss, um zur Behandlung von oberflächlicher Papillomatosis direkt in die Harnblase eingeführt werden zu können, werden besprochen. Die Verfasser zeigen, dass $Y^{90}Cl_3$ mit inaktivem Yttrium (»carrier«) und einem gelatinösen Agens (EDTA) in stabiler Lösung beibehalten werden konnte und dass nur negligierbare Absorption durch die normale Harnblase vorkam.

RÉSUMÉ

Les auteurs examinent les propriétés exigées d'une solution radioactive émettant un rayonnement béta destinée à être introduite directement dans la vessie pour traiter la papillomatose superficielle. Les auteurs montrent que $Y^{90}Cl_3$ où l'yttrium est actif et EDTA pourraient être maintenus en solution stable, absorbée seulement en quantité négligeable par la vessie normale.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: DOCENT BENGT HOLMGREN),
SABBATSBERG SJUKHUS, STOCKHOLM, SWEDEN

TRAUMATIC RUPTURE OF THE MAIN BRONCHI

by

Uno A. T. Norlin

In cases of severe chest injury the possibility of bronchial rupture should be kept in mind, especially as this is nowadays amenable to surgical treatment. The injury is not very common, but it is far more rare for the condition to be recognized clinically, owing to unfamiliarity with the lesion and to the fact that the patient is generally in such a bad condition that the examinations required to make the diagnosis are often very difficult to carry out.

The clinical picture is very much the same in all cases. There is usually a history of severe chest injury, such as a car or truck wheel passing over the chest and more seldom by a direct blow or a fall. There may be shock, dyspnea, cyanosis, and a pneumothorax may be present. If the bronchial rupture is situated within the mediastinal pleura, there may also be mediastinal emphysema. Rib fractures may or may not be present. Subcutaneous emphysema may be more or less extensive.

Many other structures of vital importance may be injured at the same time and the immediate fatality rate is high. About 50 cases have been published over the years. In 1947, KINSELLA and JOHNSRUD collected 38 cases from the literature and added 2 of their own. In this series, 4 died immediately, 5 within one hour and 10 after periods of 5 to 96 hours. Several of those surviving the immediate crises, later suffered from tension pneumothorax, mediastinal emphysema or haemorrhage and 2 lived long enough to develop pericarditis and empyema. The patients who recovered spontaneously, did so after many complications with the end-result of an atelectatic and functionless lung on the affected side. Only a few cases in this series were recognized early as true bronchial ruptures. In most of them, the diagnosis was made only at post-mortem or after months or years, in some cases 20 to 30 years after the accident. Bleeding into the pleural cavity was found in 10 of the 38 cases and of these 10 patients 7 died. Haemorrhage into the lumen of the bronchus occurred in 9 out of the 38 with 5 deaths. The site of the rupture was usually the main bronchus near the carina, with about the same frequence on the right and left sides.

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Fig. 1. Fig. 2.

Figs. 1 and 2. Case 1. Five days after the accident, opacity of atelectatic type behind the heart.

The mechanism of bronchial tear cannot of course be analyzed in detail, but in the literature two main factors are mentioned; on the one hand, compression of the bronchus between the elastic chest wall and the spine, and on the other, increased intrabronchial pressure, the tracheo-bronchial tree being converted into a closed air-filled system when the victim holds his breath and occludes his larynx before an impending blow.

The author has examined one case and has had the opportunity of seeing films of another case. As these cases may give some indication of the diagnostics of the condition, they are briefly reported.

Case 1. O. K., a boy, aged 5 years, was run over by a 3-ton truck. When he arrived at the hospital, he was in poor condition, shocked, with a pneumothorax on each side, mediastinal and subcutaneous emphysema and rib fractures. On roentgen examination 5 days after the accident (Figs. 1 and 2), the emphysema had diminished but an opacity had appeared behind the heart. He soon improved and was sent home a few days after this examination. At home, he soon became exhausted and short of breath, and was re-admitted to hospital. At this time, about one month after the accident, the left hemithorax was opaque and the mediastinum displaced to the left; only a few ml of chylous fluid could be withdrawn by aspiration. For a long period, no roentgenologic change in the appearances occurred. The patient was in good condition but short of breath on exertion. Ten months after the accident, bronchography demonstrated total occlusion of the left main bronchus (Figs. 3 and 4). At operation (CRAFOORD), the left main bronchus was found to be flattened out near the carina for a distance of about 1 cm and was surrounded by fibrous scar tissue. The atelectatic left lung was removed.

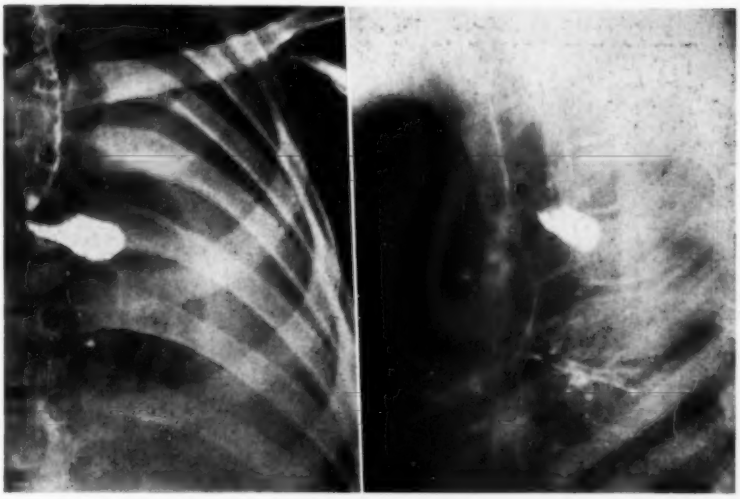

Fig. 3. Fig. 4.

Figs. 3 and 4. Case 1. Bronchography 10 months later. Total occlusion of the left main bronchus.

Case 2. K. P., a girl, aged 7 years, had been hit on the left side of the chest by the shaft of a wheel-barrow. The parents noticed that the face and chest of the child suddenly became swollen. When she arrived at the hospital she was cyanotic, dyspneic and anxious. There was a pneumothorax on the right side as well as mediastinal subcutaneous emphysema (Fig. 5). After one week, the pneumothorax persisted on the right side and there was also increased collapse of the lung (Fig. 6). A small right pleural effusion gradually developed. The lung never expanded. Her general condition was good and she was sent home with a non-functioning right lung. Some weeks later another film of the chest was obtained (Fig. 7). There was a remarkable displacement of the mediastinum to the right, the heart lying totally on the right side. There was no air in the right lung and the right main bronchus could be seen filled with air from near the carina to a point a few cm distally, where the bronchus seemed to be obliterated. Bronchoscopy was performed and the right main bronchus was observed to be occluded near the carina. She was operated upon (CRAFOORD) about 5 months after the accident. At the operation the rupture was found to be situated in the right main bronchus near the origin of the bronchus of the upper lobe. It was found possible to effect an end-to-end anastomosis of the ruptured bronchus, following which, the lung was blown up. In a routine film obtained about 6 weeks after the operation, there was only slight displacement of the mediastinum to the right. On bronchography (Figs. 8 and 9), the site of the previous rupture, near the origin of the right upper lobe bronchus, could be distinguished. There was no evidence of bronchiectasis, though this lung had been atelectatic for about 5 months.

The two cases reported may possibly be instructive from a radiologic point of view. In cases of chest injury with pneumothorax or mediastinal

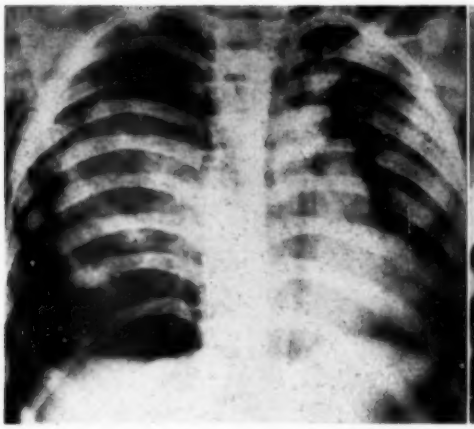

Fig. 5. Case 2. Right-sided pneumothorax with mediastinal and subcutaneous emphysema.

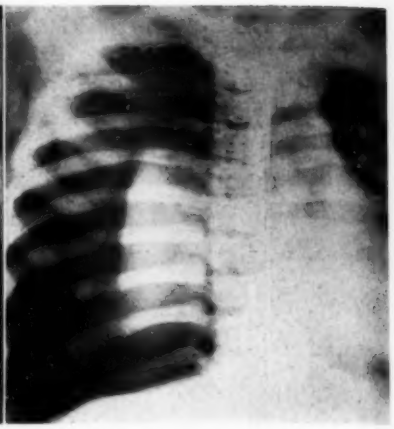

Fig. 6. One week later. Increased collapse of the right lung.

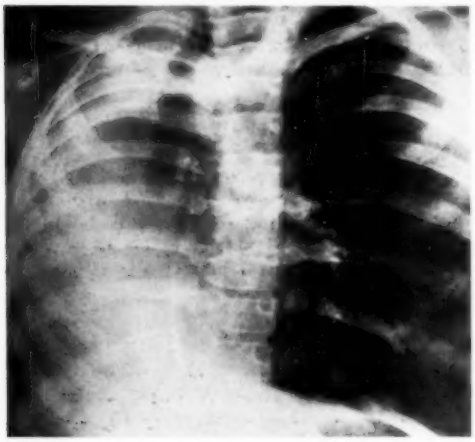

Fig. 7. Same case. Some weeks later. No pneumothorax. Atelectatic right lung with occlusion of the right main bronchus a few cm from the carina.

emphysema, films sufficiently penetrated to admit of a detailed study of the trachea and the main bronchi should always be obtained. In most cases an exact diagnosis may probably be made at an early stage. In the first of the two cases referred to, this could have been made at least at the examination which is illustrated in Fig. 1. When atelectasis appeared, conditions were favourable for a demonstration of the condition of the bronchi. There was the greatest possibility of the bronchial stenosis being shown as early as the fifth day, and without the necessity of employing contrast media. If the roentgenologist fails to demonstrate a bronchial rupture in the acute stage, the second phenomena, bronchial occlusion or bronchial deformity, may always be visualized later.

SUMMARY

The literature on rupture of the main bronchi, a rare injury, often combined with other lesions with a high mortality, is reviewed. Severe chest trauma with pneumothorax

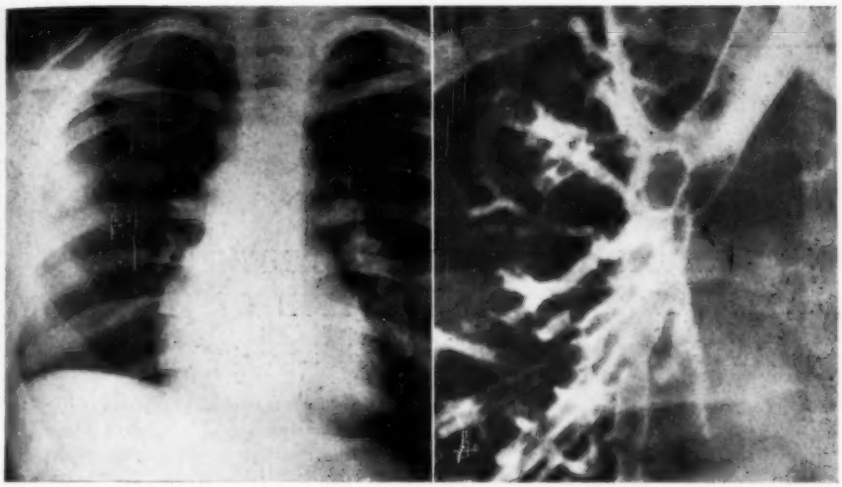

Fig. 8. Fig. 9.

Figs. 8 and 9. Bronchography after operation. Site of the previous rupture.

and persistent lung collapse should lead to the suspicion of bronchial rupture. The roentgenologist may form the diagnosis both in the acute and late stages by careful examination of the main bronchi.

ZUSAMMENFASSUNG

Die Literatur über die Ruptur der Hauptbronchen, einer seltenen Verletzung, die oft mit anderen Läsionen verbunden ist und eine hohe Mortalität hat, wird besprochen. Schwere Traumatisierung des Brustkorbes mit Pneumothorax und persistierendem Lungenkollaps sollte zur Vermutung einer Bronchialruptur führen. Der Röntgenologe kann die Diagnose sowohl in den akuten Fällen als auch in den Spätstadien auf Grund sorgfältiger Untersuchung der Hauptbronchen stellen.

RÉSUMÉ

L'auteur passe en revue la littérature concernant la rupture des grosses bronches, lésion rare, souvent associée à d'autres lésions entraînant une forte mortalité. Les traumatismes thoraciques graves avec pneumothorax et collapsus pulmonaire persistant doivent faire soupçonner une rupture bronchique. Le radiologiste peut, grâce à un examen minutieux des grosses bronches, établir ce diagnostic au stade aigu et au stade tardif.

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FROM THE GYNECOLOGIC CLINIC (DIRECTOR: PROFESSOR P. WETTERDAL), SABBATSBERG HOSPITAL, KAROLINSKA INSTITUTET, STOCKHOLM, SWEDEN

APPROXIMATE FORMULAS DESCRIBING TRANSMISSION AND ABSORPTION OF BETA RAYS

by

Erik Odeblad

Ignoring the complicated mechanisms governing the absorption of beta rays (reduction of the energy of single beta particles, complete arrest of low-energetic beta particles, elastic and inelastic scattering, shape of beta spectrum etc.) it is sometimes useful to describe the study of the phenomena in over-all transmission or absorption in simple mathematical formulas. Either the reduction of the number of particles or the energy loss of the beam of beta rays may be considered in transmission and absorption measurements.

We denote transmission of beta rays by $T(r)$, r being the distance from the source (in mg/cm²) for the particular absorber. Absorption, $A(r)$, we define as $-dT(r)/dr$. It has been customary to express $T(r)$ in an exponential form: $T(r) = e^{-\mu r}$, μ being the absorption coefficient. The exponential form is often satisfactory, especially if r is small; but if r is comparatively large, the exponential form is inadequate, since it predicts an infinite range, and all beta emitters are known to have a maximum range R (mg/cm²). A discontinuous function has previously been given (LOEVINGER, 1950) to account for the existence of the maximum range.

Approximate and simple formulas describing the whole course of transmission or absorption curves of beta rays in a continuous form have been sought by the author. Among various mathematical expressions examined, a family of binominal functions of the general form $B(r) = (1 - r/R)^r$ has been found convenient and accurate enough to warrant a report.

We need only consider the section $1 \geqq B(r) \geqq 0$ of $B(r)$, since only this part of the function has real physical meaning. All members of

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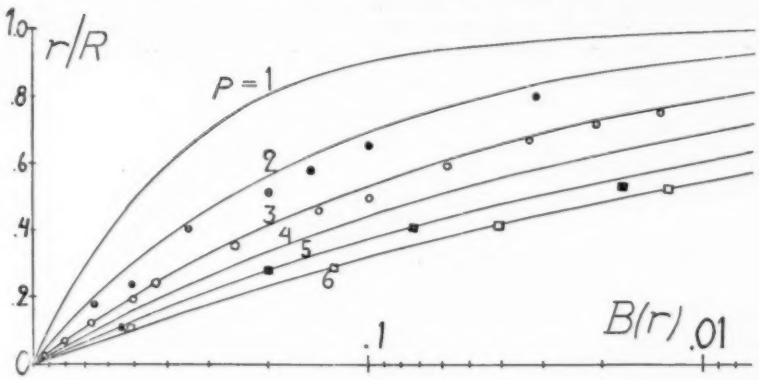

Fig. 1. The relation between r/R and $B(r)$ for various values of p (curves) and some experimental points. The filled circles are experimental values for P^{32} beta radiation in photographic emulsion, expressing $A(r)$. These experimental points are close to $p = 2$. The open circles are $T(r)$ values obtained with a P^{32} source and a Geiger-Müller counter. The absorbers were placed immediately in front of the source. Methylmethacrylate absorbers were used. The filled squares denote results obtained from a S^{35} source with a Geiger-Müller counter, the cellophane absorbers being placed immediately in front of the tube. The open squares were obtained with the same geometry but with the absorbers placed immediately in front of the source. The filled and open squares therefore illustrate that p depends on the situation of the absorber when measuring $T(r)$. The distance between the source and the tube window was about 13 mm.

the $B(r)$ family have the common properties that $B(r) = 0$ if $r = R$, and $B(r) = 1$ if $r = 0$. These properties, by definition, fit exactly for the transmission of beta rays. The members with integer p values of the $B(r)$ family are shown as curves in the semilogarithmic diagram in Fig. 1. This figure also shows some experimental points.

By differentiation of $T(r) = (1 - r/R)^p$, we find $A(r) = (p/R) \cdot (1 - r/R)^{p-1}$, *i. e.* a function of the $B(r)$ type. The relations $A(r)/T(r) = p/(R - r)$, and $A(0) = p/R$ are readily obtained.

In the application of $B(r)$ to beta ray absorption or transmission problems, the magnitude of p must be determined, either through interpolation between members of the curve family or by measuring the initial slope of the transmission curve, using the above-mentioned relation for $A(0)$. We note that the determination of p requires a measurement of R with sufficient accuracy.

The values obtained of p seem to depend on several factors. According to the results presented in Fig. 1, $T(r)$ for P^{32} beta rays has the value of 3 and $A(r)$ about 2 as best approximations for p. For S^{35} the values of 5 and 6 were obtained for two various positions of the absorber, the other factors being constant.

In our laboratory we have adopted tentatively these values and apply the binominal formulas to several problems, *e. g.* the evaluation of some quadruple integrals in autoradiography (ODEBLAD, 1952), calculation of tissue doses from radioisotopes administered internally or from beta applicators as well as for the identification of mixtures of beta emitting isotopes obtained in activation analysis. Studies are being performed on the various factors upon which p depends in order to obtain better accuracy in the applications.

SUMMARY

Transmission and absorption of beta rays are described by a binominal formula $(1 - r/R)^p$. In this formula, r is the actual and R the maximum range. p denotes an exponent, the value of which, in different cases, was between 2 and 6.

ZUSAMMENFASSUNG

Die Transmission und die Absorption von Betastrahlen werden mit Hilfe einer Binominalformel beschrieben. Diese Formel ist $(1-r/R)^p$, wo r der Abstand und R die maximale Reichweite bezeichnet. p ist ein Exponent mit dem Wert von 2 bis 6.

RÉSUMÉ

On a représenté la transmission et l'absorption des rayons béta par le binôme $(1 - r/R)^p$. Dans cette formule r désigne la distance, R l'épaisseur maximale et p un exposant. La valeur de l'exposant a varié de 2 à 6 dans différents exemples.

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FROM THE DEPARTMENT OF RADIOTHERAPY, UNITED OXFORD HOSPITALS, OXFORD, ENGLAND

THE USE OF A PERSPEX "SPREADER" APPLICATOR FOR VAGINAL RADIUM IN TREATMENT OF CARCINOMA OF UTERINE CERVIX

by

Frank Ellis and *R. Oliver*

The radium treatment of carcinoma of the cervix is now usually carried out using an intra-uterine tube and two radium tubes in the

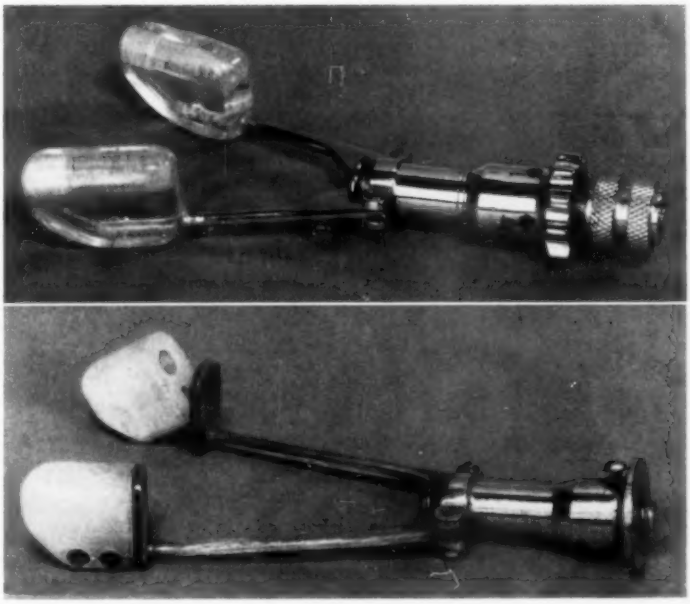

Fig. 1 (top). Perspex spreader applicator for holding vaginal radium sources.
Fig. 2 (below). Design of applicator allowing easy removal of radium sources.

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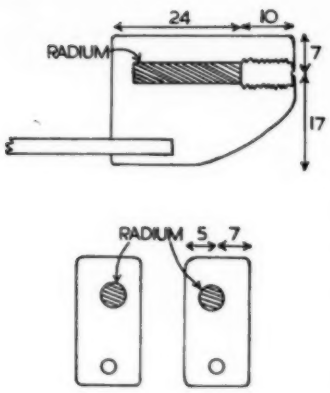
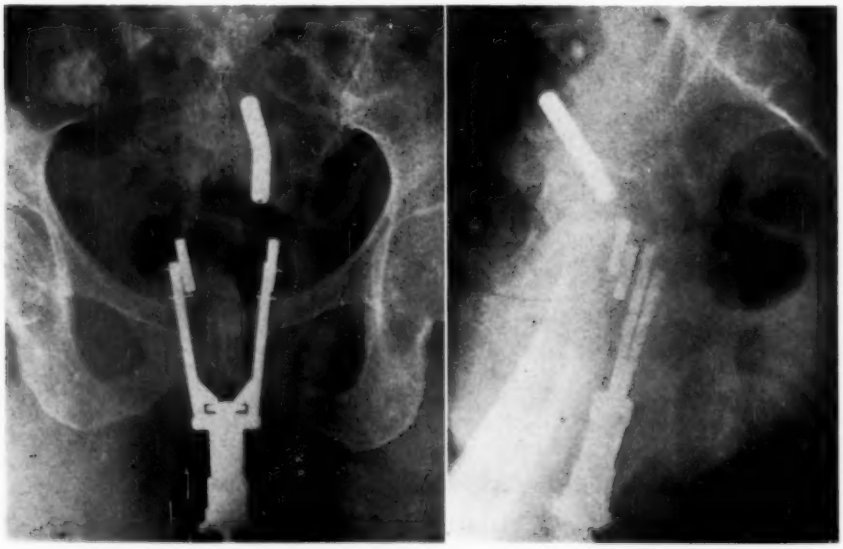


Fig. 3. Dimensions of perspex heads in mm providing lateral and posterior protection.

vagina. A number of devices and applicators have been described for positioning the vaginal sources.

Thus at Manchester (TOD and MEREDITH, 1938) the sources are in rubber ovoids which are packed into the required position, whilst DONALDSON (1933) has used a "butterfly pessary" which allows the two sources to be separated after insertion. For some 20 years one of us (F. E.) has been using a spreader applicator which has proved very convenient and practical. The photograph (Fig. 1) shows the most recent design. The Radium (standard Radio-chemical Centre type E_6 25 mg tubes) is carried in two perspex heads mounted on the spreader arms. The applicator weighs only 4 ounces and may be sterilised by boiling. It is inserted with the arms together. By means of the screw at the outer end the arms may then be opened to distend the vagina laterally, when the pressure holds the applicator



a. b.

Fig. 4 a and b. Radiographs of typical arrangement using intrauterine radium tube and two vaginal sources in perspex spreader applicator.

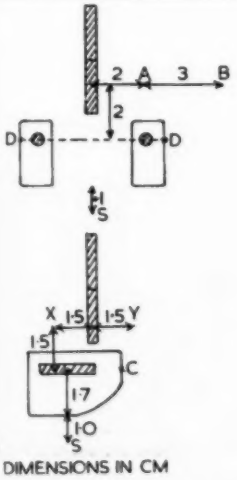
firmly in position. The radium separation is increased by 2 cm for each rotation of the screw and the barrel is calibrated so that the final spacing is known. The insertion may be made very quickly and involves the minimum of exposure to the radiotherapist.

Table 1

Calculated dose distribution with two E_6 tubes in spreader in vagina and two E_6 tubes in uterus

The intrauterine radium is assumed in a straight tube in the central plane at right angles to the plane of the vaginal radium, the tube axis being level with the physical ends of the vaginal tubes nearer the nose of the applicator.

Separation of radium in spreader	Lower end of I.U. tube above spreader radium	Dose rate r/hr.						
		A	B	X	Y	C	D	S
2 cm	0 cm	123	29.2	217.5	152.5	150.3	368.3	62.4
	1 cm	119	28.7	197	132	113.0	341.9	56.6
	2 cm	100.5	27.3	158.5	93.5	87.1	326.5	54.6
	3 cm	82	25.4	132.6	67.6	78.2	319.0	52.7
3 cm	0 cm	126.2	31.1	191.5	147.5	128.8	337.3	56.4
	1 cm	122.2	29.6	171	127	94.8	322.1	50.6
	2 cm	103.7	28.2	132.5	88.5	77.0	311.5	48.6
	3 cm	85.2	26.3	106.6	62.6	68.9	305.2	46.7
4 cm	0 cm	126.5	33.4	170.5	143.1	100.7	321.5	50.4
	1 cm	122.5	31.9	150	122.6	82.2	311.1	44.6
	2 cm	104.0	30.5	111.5	84.1	68.8	303.5	42.6
	3 cm	85.5	28.6	85.6	58.2	63.2	298.6	40.7
5 cm	0 cm	123	36.9	155.5	138.5	83.7	310.4	45.1
	1 cm	119	35.4	135	118	72.9	304.1	39.6
	2 cm	100.5	34.0	96.5	79.5	63.4	298.4	37.6
	3 cm	82	32.1	70.6	53.6	59.2	294.9	35.7
6 cm	0 cm	115.4	41.1	146.5	134.5	73.7	303.4	40.4
	1 cm	111.4	39.6	126	114	66.7	298.9	34.6
	2 cm	92.9	38.2	87.5	75.5	59.7	295.0	32.6
	3 cm	74.4	36.3	61.6	49.6	56.6	292.3	30.7



Key to points for which dose rate is given in the table.

Point A is 2 cm above the plane of the vaginal radium and 2 cm laterally from the uterine axis.
Point B is 2 cm above the plane of the vaginal radium and 5 cm laterally from the uterine axis.
Point X is 1.5 cm above the plane of the vaginal radium and in the central plane 1.5 cm from the uterine axis towards the vaginal radium.

Point Y is 1.5 cm above the plane of the vaginal radium and in the central plane 1.5 cm from the uterine axis away from the vaginal radium.

Point C is in the plane of the vaginal radium on the nose of the perspex applicator.
Point D is in the plane of the vaginal radium on the outer surface of the perspex applicator opposite to the centre of the radium tube in the applicator.

Point S is 2.7 cm below the plane of the vaginal radium (1 cm below the bottom of the perspex applicator) in the central plane and opposite the middle of the vaginal radium tube.

In this design the radium is sealed into the perspex heads and the complete container stored in a suitable lead protected carrying box. In another design shown in Fig. 2 the head may be swung open to allow the radium to be inserted, and as assembly only involves fitting a stainless steel screw with a magnetic screw driver, the loading may be performed easily and safely, with the hands at a distance from the radium.

The shape of the perspex heads (Fig. 3) has been chosen to provide for satisfactory minimum spacing of the radium from the fornix and from the lateral wall, and also to provide protection posteriorly to the rectum. Fig. 4 shows radiographs of a typical application.

As a guide to the dose rates obtained, values are given in the table for various spreader spacings when the intrauterine tube is situated centrally relative to the vaginal sources and at right angles to the plane of these sources. A fuller consideration of dose distribution for the different angulations and positions of the intrauterine source obtained in practice, will be published later.

Working drawings of the latest design (constructed by Mr. G. E. J. Jackson in our own workshop) are available from the authors.

SUMMARY

A vaginal radium applicator is described for use in treatment of carcinoma of the cervix. The radium tubes (two 25 mg sources) are carried in two perspex heads mounted on spreader arms and the final radium spacing may be read off from calibrations on the barrel of the applicator. A table gives calculated dose rates for various radium separations and relative positions of a 50 mg intrauterine source.

ZUSAMMENFASSUNG

Ein vaginaler Radiumapplikator zur Benutzung bei Behandlung des Zervixkarzinomes wird beschrieben. Die Radiumtuben (zwei 25 mg Einheiten), sind in zwei Perspexhülsen gelegen, welche auf die spreizbaren Arme des Instrumentes montiert sind. Der endgültige Abstand zwischen den Radiumpräparaten kann von Eichungen am Applikator abgelesen werden. Eine Tabelle zeigt kalkulierte Dosisleistungen für verschiedenen Radiumseparationen und relative Lagen einer intrauterinen 50 mg-Einheit.

RÉSUMÉ

Description d'un applicateur vaginal de radium pour le traitement du cancer du col. Les tubes de radium (deux sources de 25 mg) sont portés par deux têtes en perspex montées sur des branches extensibles et l'écartement final des sources de radium peut être lu sur les graduations du tambour de l'applicateur. Une table donne les doses calculées pour différents écartements des sources et pour les positions par rapport à elles d'une source intra-utérine de 50 mg.

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FROM THE CHICAGO TUMOR INSTITUTE, THE UNIVERSITY OF CHICAGO, CHICAGO, ILL., U. S. A.

CANCER OF THE LARYNX TREATED WITH TEN GRAM RADIUM PACK

Report of thirty-eight cases

by

Max Cutler, Erwin M. Japha and *Leonidas Peppas*

Thirty-eight cases of cancer of the larynx were treated by telecurietherapy before July 1, 1948, at the Chicago Tumor Institute. This is the first report of a series dealing with telecurietherapy, its technique and results, in the treatment of various forms of cancer. Since only selected cases were treated by this modality, no conclusions will be drawn as to its comparative value.

Telecurietherapy (10) uses relatively large quantities of radium at comparatively long focal distances. A more or less well-defined beam of gamma-radiation is directed accurately to deep-seated tumors with the aim of delivering a massive depth dose. When a suitable apparatus is available, telecurietherapy can be employed very much like roentgen therapy, except that the consequences of the inverse square law impose certain limitations as long as the radiating sources are no larger than 4—10 curies. Surface dose rates of at least 5—10 r/min. are required, to avoid undue strain on the patient's endurance, and allow reasonable fractionation, even with multiple portals, within a treatment period of not much more than six weeks.

Modern telecurietherapy provided much more penetrating radiation than the roentgen therapy then in common use, but this is no longer true. The radium (B + C) gamma-ray spectrum extends from 5.57 to 50.8 AU (9) and the intensities of the eleven lines are such as to fit almost exactly the intensity distribution curve of a filtered roentgen ray beam produced at 2 million volts (12), with an average quantum energy of about 1.2 MeV. A similar beam with only two very closely spaced lines issues from a cobalt-60 source, and roentgen rays of energies several

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hundred times as high are available today from electron accelerators of various kinds.

The re-definition of the roentgen unit at the Third International Congress of Radiology in Chicago (1937) made it possible to use the roentgen unit also for telecurietherapy and to link it up with roentgen therapy. It has also facilitated a comparison between different kinds of radium units.

In telecurietherapy, the surface rates depend mainly on the amount of radium and the distance employed. Filtration as used almost universally plays a minor rôle, and the same applies to the arrangement of the source.

The depth dose is made up of two components: direct beam contribution (attenuated by a distance factor and an absorption factor) and scatter. The latter is much less important with a radium gamma beam than with 200 kV roentgen rays, and will not amount to more than five per cent of the skin dose, even with larger portals.

The isodose curves are somewhat "flatter" than those from 200 kV roentgen rays. Unless special precautions are taken, a considerable "bulge" is present; but this is not necessarily a disadvantage, and can be utilized through judicious planning.

Special indications for the use of a gamma-ray beam include:

1. The more resistant types of growth.

2. Intraoral carcinoma, with bone involvement, when surgery is not advisable as a primary measure. Compared with 200 or 400 kV roentgen radiation, teleradium produces less absorption of gamma-rays in bone, and the likelihood of local "hot spots" and probably of bone necrosis is reduced.

3. Further therapy of cases previously irradiated by other modalities. A change from roentgen rays to gamma rays, or from superficial to teleradium therapy will often prove effective, as radio resistance is rarely absolute. Conversely, it may be advisable in selected cases to change from teleradium to superficial therapy or to roentgen rays.

Whether telecurietherapy is superior to therapy with roentgen rays in the 200—250 kV range is still a much debated question (11). Sir STANFORD CADE (3) could not find any conclusive evidence in either direction. WINDEYER (13) reported no significant difference of 5-year results in a series of 70 cases of intrinsic cancer of the larynx. The only truly controlled therapeutic experiment is that of the Medical Research Council group in London, under the direction of Miss CONSTANCE A. P. WOOD (14, 15). In an equal number of cases (107 each) of cancer of the mouth, larynx and pharynx — all primary and not previously treated — either the 5-gram teleradium unit was used, or roentgen rays produced first at 200, later at 185 kV. The isodose distribution of the two media was equal-

ized as much as possible. The overall 5-year cure rates estimated by BOAG's method (1, 2) from interim clinical results, and standardized for site distribution of the slightly unequal samples were: 31 per cent for the teleradium cases, 20 per cent for the cases treated by roentgen rays. Although suggestive, this difference of 11 per cent is not statistically significant. An important finding was that with equal r skin doses, given at approximately the same daily rate, the skin reactions were more severe with roentgen rays and healed more slowly. This is probably due to the higher intensity of the roentgen ray beam at depths of 0.5—2.0 mm, where the basal cells of the epidermis are located.

Teleradium calls for a fractionated type of therapy (5, 6) which until recent years necessitated considerable protraction. The purely technical disadvantages, paralleling those of COUTARD's protracted fractionated roentgen ray techniques, are somewhat intensified by the size of most units and the difficulty in application. Recent technical and quantitative advances, however, should eliminate some of these factors.

The 38 cases of cancer of the larynx are, in accord with previous publications from the Chicago Tumor Institute (8), arranged according to the classification of the Curie Institute of Paris. They are divided into cancer of the vocal cords, cancer of the laryngeal vestibule comprising the free borders and laryngeal surface of the epiglottis as well as the false cords, cancer of the ventricular cavity, and cancer of the subglottic area. Lesions of the aryepiglottic folds, pyriform fossae and postcricoid region belong to the hypopharynx and will be considered separately, together with lesions of the posterior and lateral pharyngeal walls.

Thirty-seven of the cases were primary lesions: 25 squamous cell carcinomas; 5 papillary epidermoid carcinomas; 3 anaplastic epidermoid carcinomas; 1 squamous carcinoma with transitional cell features; 2 transitional cell carcinomas; 1 atypical papilloma. One case was recurrent carcinoma. Age and sex distribution are presented in Table I.

Table I

Age and Sex Distribution

	Vestibule									
	True Cord		False Cord		Epiglottis		Ventricle		Total	
	M	F	M	F	M	F	M	F	M	F
20—29	—	1	—	—	—	—	—	—	—	1
30—39	—	—	—	—	—	—	—	—	—	—
40—49	7	—	2	—	3	—	—	—	12	—
50—59	3	—	5	—	4	—	1	—	13	—
60—69	3	—	—	—	5	—	—	—	8	—
70—79	3	—	—	—	—	—	—	—	3	—
80—89	1	—	—	—	—	—	—	—	1	—
Total	17	1	7	—	12	—	1	—	37	1

The treatment of cancer of the larynx with the ten gram radium pack was designed to permit comparison with the roentgen ray techniques then used, *i. e.*, mainly the "concentration therapy" developed by COUTARD and CUTLER (7, 8). Remaining variables include quality of radiation, and differences in distance, depth dose, and isodose distribution.

Two main techniques were developed: 1) single field; 2) double field. In an additional group the radium pack was combined with 400 kV roentgen rays. The difference between these techniques lies more in the time factor than in the total dose.

Single-Field Technique. Two variants have been used:

1. An intensive-concentration type *6 day course*, with skin doses of 3,432 to 4,840 rγ (78,000 to 110,000 mghrs) and portals of 5 $\times$ 5 and 6 $\times$ 6 cm. These cases were started on an interval course (see below), but as the tumor disappeared rapidly the second part of the course was omitted.

2. A *14—25 day course*, administering equal daily doses, up to a total of 4,620 to 6,160 rγ (105,000 to 140,000 mghrs) to the intrinsic, and up to 8,800 rγ (200,000 mghrs) to the extrinsic lesions. For the latter and some of the epiglottic cases an 8 cm round portal was used, otherwise one of 6 $\times$ 6 cm square. Treatments were usually given twice daily.

Two-Field Technique. For intrinsic lesions the two fields were generally applied directly to the contours of the neck, resulting in some angulation, whereas for epiglottic lesions the fields were applied more truly lateral.

1. Equal bilateral total dose: Depending on the actual skin dose delivered, the total time varied between *12 and 24 days*, and the total dose on either side from 3,168 to 4,840 rγ (72,000 to 110,000 mghrs). The two fields were treated concurrently, one in the morning, the other in the afternoon. As a rule the daily dose was increased in accordance with the "concentration therapy" from 2 $\times$ 132 rγ to 2 $\times$ 440 rγ (2 $\times$ 3,000 to 2 $\times$ 10,000 mghrs). No portals larger than 6 $\times$ 6 cm square were employed.

2. Unequal bilateral *23 day course:* The total skin dose was divided into 4,400 rγ (100,000 mghrs) to the side of the lesion and 1,760 to 2,640 rγ (40,000 to 60,000 mghrs) to the opposite side (the higher dose being used in extrinsic lesions) treated consecutively. An 8 cm round portal was often used in this group.

3. Interval course: This type of treatment was in the first place devised for presumably radio-resistant lesions, in order to deliver high daily doses over a short period and, with favorable response, to administer another short high-intensity cycle of radiation after an interval of about 12 days; failing response, laryngectomy was advised. The first cycle usually lasted six days, the second four to five days, the overall time from

Fig. 1. (Case 1) Skin reaction on 33rd day.

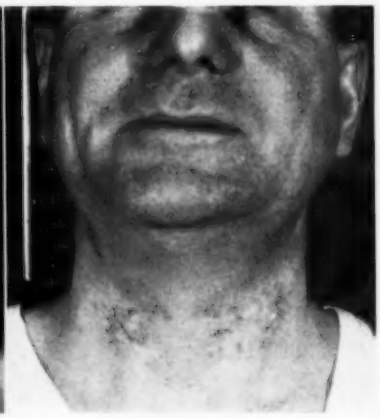

Fig. 2. (Case 2) Condition of skin after 8 years.

19—27 days. Concentration type fractionation was used with increasing daily doses and diminishing field sizes. The side of the neck mainly affected was treated first, the opposite side at the second cycle. During the second cycle usually a higher dose was delivered by 440 rγ (10,000 mghrs), the total skin doses varying from $2 \times 3{,}168$ rγ ($2 \times 72{,}000$ mghrs) to $4{,}400 + 4{,}840$ rγ ($100{,}000 + 110{,}000$ mghrs).

Slower variants of some of these techniques, with treatment lasting from five to eight weeks, were used in three of the more advanced cases, mainly with palliative intent.

Tumor Dose. The tumor dose was estimated for the various techniques, basing the distance on the average neck and larynx rather than on individual measurements. Detailed information is contained in Table II. For intrinsic lesions of the larynx the minimum and maximum doses refer generally to the anterior and posterior ends of the cords. For epiglottic lesions the dose distribution was more homogeneous, and minimum and maximum doses, where stated, refer to the different dose levels of various techniques.

An analysis of results shows that all cures were obtained with overall treatment times of less than 24 days. Only one patient, with an interval course extending over 27 days, remained well for seven years, when recurrence developed. The protracted courses were generally applied to the more advanced cases.

Response varied depending on location of the lesion. In carcinoma of the true cord, a six day course, delivering a minimum tumor dose of

Table II

Larynx Treatment Schemes and Tumor Doses

Skin Dose	Technique	Total Number	Cords Mobile	Died of Other Causes Within 5 Years	Alive & Well 5 Years	Tumor Dose Min.	Tumor Dose Max.	Total Treatment Time	N	T
Single-Field Technique										
1 3,432—4,840 rγ	c	2	2	—	2*	2,360 rγ —3,325 rγ	2,640 rγ —3,725 rγ	6 days	—	—
2 4,620—6,160 rγ	e	4	1	—	—	L 3,550 (E 2,440	—4,745r γ) —3,220r γ)	14 to 25 days	1	2
Two-Field Technique										
1 Equal (concurrent) ... 2 × 3,168—2 × 4,840 rγ	(13 c) (1 e)	14+	13	4	7#	L 3,670 4,850 rγ (E 2,520	4,685 —6,220 rγ —3,600 rγ)	12 to 24 days	—	—
2 Unequal (consecutive) 4,400 + 1,760 to 2,640 rγ	e	6	2	—	—	L 3,660 (E 2,625 rγ)	—,4650 rγ	23 days	—	1
Interval Course										
2 × 3,168 to..... 4,400 + 4,840 rγ.....	(8 c) (1 e)	9	6	1	3ξ	L 3,670 —5,360 rγ (E 3,400 rγ)	4,685 —6,830 rγ	19 to 27 days	4	1
Slower Variants (palliative) Two-Field Technique										
1 Equal (concurrent) ... 2 × 6,160 rγ	e	1	1	1	—	5,600 rγ	—7,150 rγ	39 days	—	—
2 Unequal (consecutive) 4,444 + 2,508 rγ	e	1	—	—	—	4,030 rγ	—5,200 rγ	53 days	—	—
Interval Course										
6,854 + 31,818 rγ (abandoned).....	e	1	1	—	—	6,280 rγ	—8,000 rγ	40 days	1	1

* Laryngofissure for recurrence 7 years later in one case.
\+ One case deep roentgen therapy for node.
\# One case had laryngectomy and postoperative roentgen therapy within 6 months for a radio-resistant lesion (E).
ξ Deep roentgen therapy in one case; laryngectomy for recurrence, 2 years later, in another case
c Concentration therapy.
e Treatment by equal doses.
N Developed necrosis.
T Needed tracheotomy after treatment.
L Larynx (intrinsic).
E Epiglottis.

3,325 rγ, proved successful. A tumor dose of 3,180 rγ, applied in 17 days, was insufficient, but a dose of 3,660 rγ proved successful if given in 13 days, as well as doses of between 4,850 and 5,500 rγ administered in 21 days. Still higher doses administered in the same time usually resulted in necrosis, with the disease persisting even in comparatively early cases.

Due to the more radiosensitive types of neoplasms usually encountered in that location, cures in carcinoma of the epiglottis were achieved by tumor doses (admittedly more difficult to estimate by the method which had to be adopted) of 2,520 rγ in 13 days, 3,600 rγ in 21 days, and 2,625 rγ given in an overall time of 23 days. All early cases of epiglottic carcinoma were cured locally.

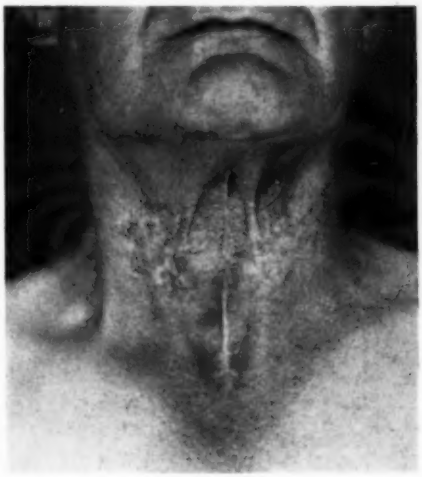

Fig. 3. (Case 3) Condition of skin 11 years after original treatment, and 4 years after laryngofissure, performed for local recurrence.

Local Reactions. In the skin, erythema developed in all cases within 12—25 days after start of therapy, with no close relationship to the rate of treatment. As erythema became intensified, a moist "epidermite" developed in most cases (Figure 1) between the third and fifth week of treatment, but healed within 7—31 days. Late slight teleangiectasis was less marked in cases treated with bilaterally equal doses than following an interval course with its higher rate of delivery (Figure 2). Surgery can be performed without difficulty in a field irradiated by the methods here described, as demonstrated by two cases in which postoperative healing was entirely uneventful (Figure 3). In the mucous membrane, an "epithelite" developed usually at the site of the lesion between the 12th and 18th day after the start of treatment, and lasted from 3—25 days.

Immediate Response. Complete regression of the local lesions was obtained in 23 of the 38 cases of carcinoma of the larynx; there was marked regression in two cases, whereas the remainder showed only slight, slow, or incomplete regression.

Results

The results are presented separately for true cord and vestibular neoplasms in Tables III and IV. Cases are divided into three groups: 1. Movable cords or epiglottis (early cases), including some more advanced lesions with partial impairment of mobility of cords; 2. Complete fixation of cords; and 3. Cases with metastases to cervical nodes. The vestibular group includes one tumor arising in the laryngeal ventricle.

Late recurrences are comparatively rare in intrinsic carcinoma of the larynx. The method of telecurietherapy here described failed to cure

Table III

Cancer of the Larynx — True Cord Lesions

	All Cases	Early (Cords Mobile or Partly Fixed)			Complete Fixation of Cords		Metastatic Lymph Nodes	
		Total	Alive and Well	Died of Other Causes	Died of Cancer	Total	Died of Cancer	Total	Died of Cancer
3-Year Results in 18 Cases									
Treatment Technique									
Single-Field:									
1 6 day course	2	2	2*	—	—	—	—	—	—
2 14—25 day course..	3	1	—	—	1	2	2+	—	—
Two-Field:									
1 Equal (concurrent) . 12—24 day course	8	8	5	3	—	—	—	—	—
2 Unequal (consecutive) 23 day course .	1	1	1	—	—	—	—	—	—
3 Slow Variant (bilateral) 8 week course..	1	—	—	—	—	—	—	1	1
Interval Course:									
19—27 days	3	3	2*	—	1	—	—	—	—
Totals	18	15	10	3	2	2	2	1	1
5-Year Results in 10 Cases									
Treatment Technique									
Single-Field:									
6 day course.....	—	2	2*	—	—	—	—	—	—
Two-Field:									
1 Equal (concurrent)..	—	5	5	—	—	—	—	—	—
2 Unequal (consecutive).....	—	1	—	—	1	—	—	—	—
Interval Course	—	2	2*	—	—	—	—	—	—
Totals	—	10	9	—	1	—	—	—	—

* One case in each group had surgery for recurrence, 2 and 7 years later, respectively. The earlier recurrence was resistant to roentgen therapy and laryngectomy; in the other case laryngofissure was performed. Both have been well 3 and 4 years, respectively.

\+ One case required supplementary roentgen therapy (1,000 r skin dose in 3 days), 2 months later.

cases with complete fixation of the cords or lymph node involvement. However, a high cure-rate was obtained in the earlier lesions. Cures in vestibular lesions were restricted to carcinoma of the epiglottis.

Complications

In two cases tracheotomy had been previously performed; in five additional cases tracheotomy became subsequently necessary, in three of these on account of necrosis with or without recurrence. In one in-

Table IV

Carcinoma of the Laryngeal Vestibule

	All Cases	Early (Cords Mobile or Partly Fixed)					Complete Fixation of Cords		Metastatic Lymph Nodes		
		Total	Alive and Well	Died of other Causes	Died of Cancer	Alive with Lymph Node Metastases	Total	Died of Cancer	Total	Alive with Cancer	Died of Cancer
3-Year Results in 20 Cases											
Treatment Technique											
Single-Field:											
23 day course	1	—	—	—	—	—	1	1	—	—	—
Two-Field:											
1 Equal (concurrent) 14—25 day course	6	5	3+	1	—	1	—	—	1	—	1
2 Unequal (consecutive) 23 day course	5	1	1	—	—	—	3	3	1	—	1
Interval Course:											
19—27 day course	6	3	1#	—	2*	—	2	2	1	1	—
Slow Variants:											
palliative	2	—	—	—	—	—	—	—	2	—	2
Totals	20	9	5	1	2	1	6	6	5	1	4
5-Year Results in 7 Cases											
Treatment Technique											
Two-Field:											
1 Equal (concurrent) ...	—	4	2	1	1	—	—	—	—	—	—
2 Unequal (consecutive).	—	1	—	—	1	—	—	—	—	—	—
Interval Course	—	1	1#	—	—	—	—	—	1	—	1
Totals	—	6	3	1	2	—	—	—	1	—	1

* One case had supplementary roentgen therapy: 4,000 r skin dose in 4 days on a 3 × 5 cm field (400 kV), 3 weeks later.

\+ One case proved radio-resistant, and total laryngectomy followed by roentgen therapy was performed elsewhere within 6 months.

\# Supplementary small field roentgen therapy (400 kV; 4 × 750 r within 28 hours), 3 weeks later.

stance treatment had to be interrupted for emergency tracheotomy. Necrosis of the epiglottis or larynx proper developed in six cases, mostly following the interval type of treatment, in which very high doses are used.

Case Reports

Case 1. R. C. R., male, 53 years old. Carcinoma of right vocal cord, whole length, filling ventricle and extending to free margin of false cord, with slight loss of mobility of right hemilarynx. Lesion bulky, papillary, protruding into glottic and subglottic space.

Histologic diagnosis: anaplastic papillary epidermoid carcinoma. Treatment: single-field technique; 6 × 6 cm portal; twice daily doses of 308—484 rγ each to a total of 4,840 rγ (110,000 mghrs) with an estimated tumor dose of 3,325—3,725 rγ in 6 days. Tumor regressed rapidly and disappeared completely. Skin reaction on 33rd day, from start of treatment. Thick dry scaling, but never open "epidermite". Patient alive and well, more than 7 years later.

Case 2. H. L., male, 47 years old. Epidermoid carcinoma of anterior two-thirds of left vocal cord, which is freely movable. Treatment by interval course technique, concentration therapy type: 3,700 rγ (84,000 mghrs) to left neck in 6 days; 9 days interval, then: 3,850 rγ (92,000 mghrs) on decreasing field in 4 days (total elapsed time 19 days) to right neck. "Epidermite" developed only on first treated side, and healed within 2 weeks. No evidence of disease 8 years later.

Case 3. G. J., male, 48 years old. Papillary plexiform epidermoid carcinoma of left true cord, involving entire length, except for posterior fifth, and invading ventricular cavity and edge of left false cord; no loss of mobility. Treatment by interval course, concentration therapy type: 2 × 3,168 rγ (72,000 mghrs) in 6 days each over total elapsed time of 26 days. Bilateral moist "epidermite". No evidence of disease 11 years later.

Discussion

The question has been raised why large amounts of radium should be used when this type of treatment can be so nearly paralleled by roentgen rays. It is impossible to make an accurate comparison between the two methods, when many factors cannot be adequately controlled, particularly variations in the stage of the disease, radiosensitivity, and unknown biological components. One form of irradiation does not necessarily exclude the other, each possessing both advantages and disadvantages. The advent of radioactive cobalt solves some of the problems, but creates others. Experience with telecurietherapy forms the basis for clinical research with radioactive cobalt (4).

Acknowledgement

The present research was made possible through the extreme generosity of the Union Minière du Haut Katanga, Brussels, Belgium, which in 1937 placed ten grams of radium at the disposal of the Chicago Tumor Institute. The trustees and supporters of the Institute acknowledge with a deep sense of gratitude this unusual opportunity. We are also grateful to the Radium Chemical Company, Inc., New York, for their co-operation. This study has been supported by grants from the National Cancer Institute, the Damon Runyon Cancer Fund, the Jennie Rubinstein Memorial Association, the Della Kossack Memorial Association, and the Louis A. Weiss Memorial Hospital.

SUMMARY

The technique and results of telecurietherapy in 38 cases of cancer of the larynx, treated before July 1, 1948, are reported. With one exception, all cures were obtained with an overall treatment time of less than 24 days. Late recurrences, after three years, were comparatively rare. In this group of cases with cancer of the larynx, many of the

lesions were advanced, and thus a false impression of the value of the modality can easily be gained. Yet, due to its facility and reliability, telecuriethérapy is a very effective and practical mode of treatment.

ZUSAMMENFASSUNG

Die Technik und die Ergebnisse der Telecuriethérapie in 38 vor dem 1. Juli 1948 behandelten Fällen mit Larynxkarzinomen werden berichtet. Mit einer Ausnahme wurden alle Heilungen in einer Gesamtbehandlungszeit von weniger als 24 Tagen erzielt. Rezidive traten nach 3 Jahren und später verhältnismässig selten auf. In dieser Gruppe von Larynxkarzinomen waren viele Fälle mit weit fortgeschrittenen Veränderungen, wodurch leicht ein fälschlicher Eindruck über den Wert der benutzten Methode gewonnen werden kann. Die Telecuriethérapie ist jedoch auf Grund ihrer Einfachheit und Zuverlässigkeit eine sehr effektive und praktische Behandlungsmethode.

RÉSUMÉ

Les auteurs présentent leur technique et leurs résultats de télécuriethérapie dans 38 cas de cancer du larynx, traités avant le 1er juillet 1948. A une exception près, tous les traitements ont été réalisés en une durée totale de moins de 24 jours. Les récidives tardives, après trois ans, ont été relativement rares. Dans ce groupe de cas de cancer du larynx, beaucoup des lésions étaient avancées, ce qui pourrait facilement donner une impression inexacte de la valeur de ce traitement. Cependant, en raison de sa facilité et de sa sûreté, la télécuriethérapie est un mode de traitement très efficace et pratique.

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AUS DER CHIRURGISCHEN UNIVERSITÄTSKLINIK (DIRECTOR: PROF. DR. H. KUNTZEN), JENA, DEUTSCHLAND

DIE FÖRDERLICHE RADIOLOGISCHE VERGRÖSSERUNG BEI FOKUSDIMENSIONEN UNTER 0.3 MM

von

K. Aderhold

Mit zunehmender Anwendung der 0.3 mm Feinfokusröntgenröhre in der medizinischen Diagnostik ist von einer Anzahl Autoren über die Prinzipien und die Vorteile der radiologischen Vergrösserungstechnik berichtet worden (VAN DER PLAATS, SCHOBER, ZIMMER, ZORN). Dabei steht im Vordergrund der Diskussion die Frage, ob auf der radiologischen Vergrösserungsaufnahme mit dem 0.3 mm Feinfokus wirklich mehr Details zu erkennen sind als auf der normalen Röntgenaufnahme. BÜCHNER kommt zu dem Schluss, dass bei folienlosen Aufnahmen die radiologische Vergrösserung mit der 0.3 mm Feinfokusröntgenröhre der normalen Röntgenaufnahme mit dem 1 oder 2 mm Fokus unterlegen ist. Lediglich die Kombination von Feinfokus und Verstärkerfolie bringt bessere Ergebnisse als die folienlose Aufnahme mit dem Normalfokus. Wie SCHOBER am Phantom mit dem 0.3 mm Feinfokus nachwies, ist die Kombination einer Feinfokusröntgenröhre mit Verstärkerfolie der Kombination von normalem Fokus und folienlosem Film dann überlegen, wenn die Direktvergrösserung möglichst gross (über 1.3) gewählt wird. Die Grenze der förderlichen radiologischen Vergrösserung ist bei dem 0.3 mm Feinfokus aber bereits mit einem Abbildungsmassstab von 2 : 1 erreicht. Abbildungen über das 2.5-fache hinaus zeigen eine störende Unschärfe und sind diagnostisch nicht zu verwerten.

Der Vorteil einer radiologischen Vergrösserung wird erst bei Abbildungsmassstäben grösser als 2 : 1 offensichtlich. Stärkere radiologische Vergrösserungen als 2 : 1 sind aber nur dann möglich und sinnvoll, wenn eine Röntgenröhre mit sehr kleinem Fokus zur Verfügung steht.

Bei der Red. am 21. März, 1954 eingegangen.

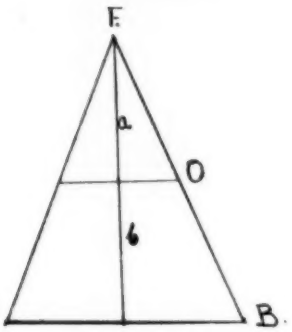

Diagramm 1.

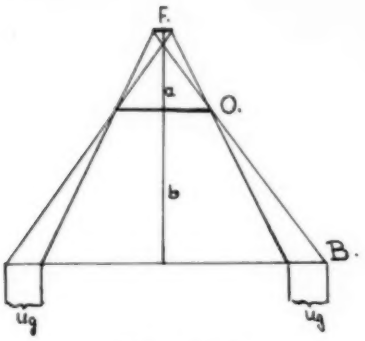

Diagramm 2.

Über die Leistungsfähigkeit einer neuentwickelten Feinstfokusröntgenröhre für Abbildungsmassstäbe grösser als 2 : 1 wurde von uns bereits andernorts berichtet (ADERHOLD-SEIFERT). Der kleinste Fokus dieser Röhre besitzt eine Kantenlänge von nur 0.03 mm. Durch eine vom Schalttisch aus stetig regelbare elektrostatische Fokussierung des Elektronenstrahls kann die Fokusdimension beliebig zwischen 1 mm und 0.03 mm eingestellt werden. Damit besteht die Möglichkeit einer optimalen Anpassung der Röhre bei dem jeweils gewünschten Abbildungsmassstab.

Die förderliche radiologische Vergrösserung ist eine Funktion der Fokusdimension und der Film- bzw. Folienunschärfe. Sie ergibt sich aus folgenden Überlegungen.

Während bei einem ideal punktförmigen Fokus ein Objekt durch entsprechende Lage zwischen Fokus und Film nach dem Strahlensatz

$$V = \frac{a + b}{a} \tag{1}$$

beliebig radiologisch vergrössert werden kann (Diagramm 1), setzt dem bei den gebräuchlichen quadratischen oder rechteckigen Fokusgrössen die geometrische Unschärfe eine Grenze (Diagramm 2). Der Rand des Objektes erscheint hier nicht mehr als eine scharfe Schattengrenze, sondern als ein mehr oder weniger breites Halbschattengebiet neben dem Kernschatten. Die Grösse dieser Rand- bzw. geometrischen Unschärfe ergibt sich zu

$$u_g = F \frac{b}{a} = F\,(V - 1) \tag{2}$$

Die geometrische Unschärfe macht sich bei einer Röntgenaufnahme jedoch erst dann störend bemerkbar, wenn sie grösser ist als die Film-

bzw. Folienunschärfe, die sogenannte innere Unschärfe, die bei der Absorption der Röntgenstrahlen im Aufnahmematerial zustande kommt. Feinzeichnende Folien besitzen immer noch eine Unschärfe von etwa 0.3 mm. Bei Verwendung von Sinofilm beträgt die Unschärfe 0.2 mm. Die geometrische Unschärfe ist bei einer sinnvollen Röntgenaufnahme etwa gleich der inneren Unschärfe (u_i) des Aufnahmematerials. Demnach ist

$$u_g = u_i$$
$$F \cdot \frac{b}{a} = u_i$$
$$\frac{b}{a} = \frac{u_i}{F}$$

Nimmt man die Gleichung (1) $V = \frac{a+b}{a} = \frac{b}{a} + 1$ hinzu, dann erhält man als Begrenzung der förderlichen radiologischen Vergrösserung

$$V_{max} = \frac{u_i}{F} + 1$$

Die Abhängigkeit der förderlichen radiologischen Vergrösserung von der Fokusdimension und der Film- bzw. Folienunschärfe (innere Unschärfe u_i) sowie das jeweilige Auflösungsvermögen zeigt die folgende Tabelle.

Tabelle

Fokusdimension mm	Auflösg.	u_i ges.	0,03		0,01		0,03	
			V.	Aufl.	V.	Aufl.	V.	Aufl.
Röntgenfilm	0.4	0.56	1.67	0.33	3	0.186	7.7	0.073
Feinkornfolie	0.6	0.84	2	0.42	4	0.21	11	0.076
Leuchtschirm	1.2	1.7	3	0.57	7	0.24	21	0.081

Es ist also die förderliche radiologische Vergrösserung von der Fokusdimension und der Film- bzw. Folienunschärfe abhängig, so dass eine bestimmte Kombination zu einer bestimmten förderlichen radiologischen Vergrösserung mit einer entsprechenden Auflösung führt. Die Auflösung ergibt sich aus der Gesamtunschärfe, dividiert durch den Vergrösserungsgrad. Mit den bisher zur Verfügung stehenden Feinfokusröntgenröhren (0.3 mm) ist bei Verwendung von Feinkornfolien mit einer Unschärfe von 0.3 mm lediglich die angegebene doppelte Vergrösserung möglich und sinnvoll. Feinstfokusröntgenröhren mit einer regelbaren Fokusdimension bis 0.03 mm gestatten demgegenüber bedeutend stärkere direkte Vergrösserungsaufnahmen (Kurve).

Unsere Erfahrungen stimmen mit denen des Schrifttums überein, dass bei Verwendung von Filmmaterial mit feinem Korn und geringer Folienunschärfe (Sinofilm) mit der 0.3 mm Fokusdimension keine Ver-

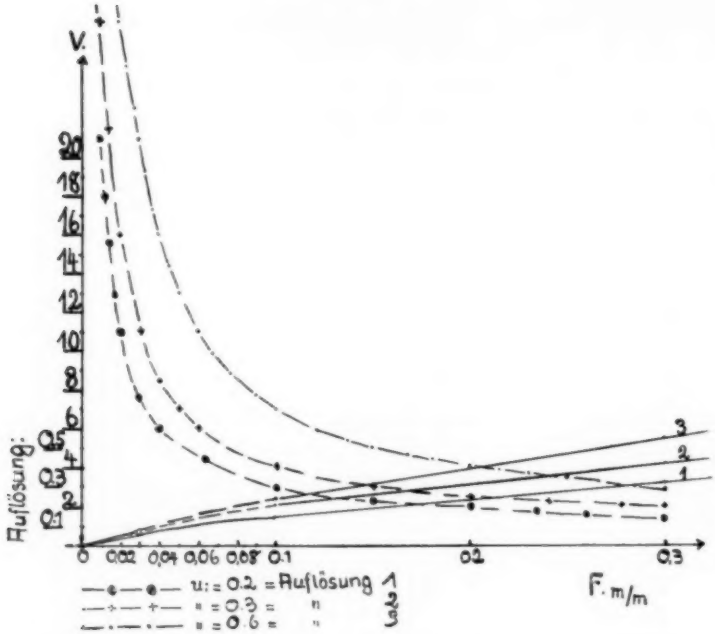

Diagramm 3. Die Abhängigkeit der förderlichen radiologischen Vergrösserung von der Fokusdimension und der Film- bzw. Folienunschärfe und das entsprechende Auflösungsvermögen.

besserung der Detaildarstellung gegenüber dem üblichen 1 oder 2 mm Normalfokus zu erzielen ist. Eine Verbesserung der Detailerkennbarkeit tritt aber ein, wenn man mit Fokusgrössen unter 0.1 mm arbeitet (Abb. 2).

Abb. 1. Daumengrundgelenk. 2 mm Fokus, Agfa-Durofilm.

Abb. 2. Dasselbe Daumengrundgelenk wie Abb. 1, 0.05 mm Feinstfokus, Agfa-Durofilm.

Abb. 3. Daumengrundgelenk wie Abb. 1, 0.05 mm Feinstfokus, Agfa-Durofilm mit Sinegran-Fina-Folie. Abb.-Massstab 4 : 1. Originalgrösse.

Obwohl die folienlose Aufnahme bei Fokusdimensionen unter 0.1 mm der folienlosen 0.3 mm — und Normalfokusaufnahme überlegen ist, erweist sich, um auf kurze Belichtungszeiten zu kommen und die mAs-Zahl und damit die eingestrahlte Dosis möglichst klein zu halten, hier die Verwendung von Filmmaterial mit feinem Korn nicht am Platze. Wie aus der Tabelle und Kurve hervorgeht, ermöglichen grobkörnige Folien mit grosser Folienunschärfe eine stärkere radiologische Vergrösserung. Grobkörnige Folien sind empfindlicher als feinkörnige und lassen

Abb. 4. Daumengrundgelenk wie Abb. 1, 0.03 mm Feinstfokus, Agfa-Durofilm mit Sinegran-Fina-Folie. Abb.-Massstab 7 : 1, Originalgrösse.

kürzere Belichtungszeiten zu. Der Sinofilm zeichnet schärfer als die Folienaufnahme, ist aber kontrastärmer und verlangt bedeutend längere Belichtungszeiten. Der geringe Schärfeverlust der Folienaufnahme wird durch den erhöhten Kontrast wieder ausgeglichen. Eine direkte radiologische Vergrösserungsaufnahme ist dann von Wert, wenn man mit starken Vergrösserungen arbeitet und die förderliche radiologische Vergrösserung ausnutzt (Abb. 3 u. 4).

Zwischen Aufnahmen mit dem 0.03 mm Feinstfokus und dem 2 mm und 0.3 mm Fokus besteht ein bedeutender Unterschied in der Detaildarstellung. Man beachte die Strukturen in den Sesambeinen.

Bei der jeweils gewählten Fokusdimension lässt sich durch Vergrösserung des Objekt—Filmabstandes so lange für alle fokusgrösseren Details eine Vergrösserung erzielen, als die Randunschärfe (geometrische Unschärfe) nicht einen bestimmten Grenzwert überschreitet. Die förderliche radiologische Vergrösserung bei einer Fokusdimension von 0.05 mm entspricht einem Abbildungsmassstab von 7 : 1, das heisst, bis zu diesem Abbildungsmassstab ist bei dieser Fokusdimension und Verwendung von Feinkornfolie mit einer Unschärfe von 0.3 mm noch eine radiologische Vergrösserung sinnvoll und möglich. Wird das Objekt näher an die Filmkasette herangebracht, dann nehmen der Abbildungsmassstab und zwangsläufig die Randunschärfe ab, das Objekt wird etwas schärfer abgebildet als wenn es filmferner liegt. Es ist aber kontrastärmer, denn das mit starkem Streustrahlenanteil abgebildete Objektdetail gibt einen geringeren Schwärzungskontrast als bei grösserem Objekt—Filmabstand, wo die bildverschleiernde Wirkung der Streustrahlen sich nicht auswirkt. Das bisher Gesagte gilt für die Darstellung fokusgrösserer Details. Auf die Darstellbarkeit fokuskleinerer Details soll hier nur kurz eingegangen werden. Wie Büchner feststellt, liefert der 0.3 mm Feinfokus bereits bei Details von 0.1 mm keinen echten, sondern einen sogenannten Pseudokernschatten. Nach Schober kann aber der Pseudokernschatten lediglich auf das Vorhandensein, nicht aber auf Form und Grösse des Objektdetails hinweisen. Man wird kontrastarme und sehr kleine Details bei der direkten Vergrösserungsaufnahme nur dann besser erkennen als im unvergrösserten Zustand, wenn der Durchmesser des betreffenden Objektdetails nicht unter dem des Fokus liegt. Gegenüber dem 0.3 mm Fokus ergibt der 0.03 mm Feinstfokus noch von 0.01 mm grossen Objektdetails einen echten Kernschatten. Zwangsläufig übereinstimmend mit der förderlichen radiologischen Vergrösserung ist die Darstellbarkeit kleinster Objektdetails von der Fokusdimension und der Film- bzw. Folienunschärfe abhängig.

Die benutzte Fokusgrösse lässt sich aus dem Vergrösserungsgrad und der Bildschärfe entnehmen. Eine 6-fache radiologische Vergrösserungs-

Abb. 5. Carpo-Metacarpalgelenke 1—3. Feinstfokus 0.05 mm, Agfa-Durofilm mit Sinegran-Fina-Folie, Abb.-Massstab 4 : 1, Originalgrösse.

aufnahme mit ausgezeichneter Bildschärfe kann zum Beispiel nur mit einer Fokusdimension von 0.05 mm oder darunter erzielt werden.

Wie hoch man die Vergrösserung treibt, richtet sich einmal nach der zur Verfügung stehenden Fokusdimension und zum anderen nach diagnostischen Schwierigkeiten. Bei den 0.3 mm Feinfokus liegt die Grenze des möglichen Vergrösserungsgrades bereits bei einem zweifachen Abbildungsmassstab. In einer Reihe von Fällen sind aber Abbildungsmassstäbe darüber hinaus, wie sie jetzt der regelbare 0.03 mm Feinstfokus ermöglicht, wünschenswert. Bei relativ dicken Objekten macht sich allerdings eine innere Objektverzerrung dadurch bemerkbar, dass filmferne Objektdetails mehr als filmnahe vergrössert werden. Die radiologische Vergrösserungsaufnahme wirkt plastisch.

Nicht nur die Strukturabmessungen, sondern auch die Kontraste werden mit vergrössert und supralaminär. Der Wert der stärkeren direkten Röntgenvergrösserung als 2 : 1 mit sehr kleinen Fokusdimensionen liegt in der Verbesserung der Detaildarstellung. Auch von minimalsten Feinstrukturen lassen sich stets optimale Aufnahmen erzielen. Die ana-

Abb. 6. Grosszehengrundgelenk bei schwerer arteriosklerotischer Durchblutungsstörung, Feinstfokus 0.03 mm, Agfa-Durofilm mit Sinegran-Fina-Folie, Abbildungs-Massstab 6 : 1, Originalgrösse.

Abb. 7. Zerstörungsherd in der Mittelphalanx des Fingers, 2 mm Fokus, Kodak-Diavidox-Film.

tomischen Verhältnisse sind besser und schneller zu beurteilen. Gegenüber der optischen Nachvergrösserung ist die Überlegenheit nicht nur in dem geringeren technischen Aufwand gegenüber den optischen Nachvergrösserungsverfahren zu sehen, sondern vor allem in der Tatsache, dass die optische Nachvergrösserung niemals im Sinne der Darstellung minimalster Details eine förderliche Vergrösserung sein kann. Wie unsere Aufnahmen zeigen werden, lassen sich mit den handelsüblichen Filmen und Folien einwandfrei scharf gezeichnete Vergrösserungen gewinnen. Wir sind in der Mehrzahl der Fälle nicht über Abbildungsmassstäbe 4—6 : 1 hinausgegangen. Einige Beispiele mögen die Leistungsfähigkeit der neuen regelbaren Feinstfokusröntgenröhre demonstrieren, wenn auch die Abbildungen nicht vermögen, ganz das wiederzugeben, was der Film selbst zeigt.

Die folgende Aufnahme (Abb. 6) eines Grosszehengrundgelenkes lässt eine ausgezeichnete Zeichenschärfe erkennen. Die Spongiosabälkchen stellen sich im Köpfchenbereich des 1. Metatarsus wie der verknöcherten Sesambeine ungewöhnlich deutlich dar.

Bei röntgendiagnostisch problematischen Fällen liegt der Wert der stärkeren radiologischen Vergrösserung in der Möglichkeit der Darstellbarkeit von Feinststrukturen, die sonst nicht darstellbar sind. Die folgende Abbildung 7 zeigt einen tuberkulösen Zerstörungsherd in der Mittelphalanx eines Fingers. Nach der üblichen Fokusaufnahme ist eine Entscheidung, ob es sich um eine Tuberkulose oder um eine Tumormetastase handelt, nicht sicher zu fällen. Gegen eine Tuberkulose könnte der noch gute Kalkgehalt des Knochens ausserhalb des Zerstörungsherdes sprechen. Die vierfache Vergrösserungsaufnahme zeigt eine Verbesserung der Detailerkennbarkeit. Die Spongiosabälkchen brechen zum Herd hin teils scharf ab oder sind abgeflacht und breit abgetragen. In dem mit strukturlosen Knochenkalkmassen angefülltem Defekt liegen zahlreiche kleinkörnige Sequester. Auch die Beurteilung der Weichteile ist ausgezeichnet möglich.

Bisher stand nur der 0.3 mm Fokus zur Verfügung, für den die anfangs hervorgehobenen Feststellungen BÜCHNERS zutreffen. Mit der Konstruktion und Anwendung der regelbaren 0.03 mm Feinstfokusröntgenröhre ist eine bisher nicht erreichbare direkte Röntgenvergrösserung möglich geworden. Die stetige Regelbarkeit der Fokusdimension ermöglicht eine individuelle Anpassung der Röhre bei dem jeweils gewünschten Abbildungsmassstab. Es lassen sich unter Verwendung von Feinkornfolien

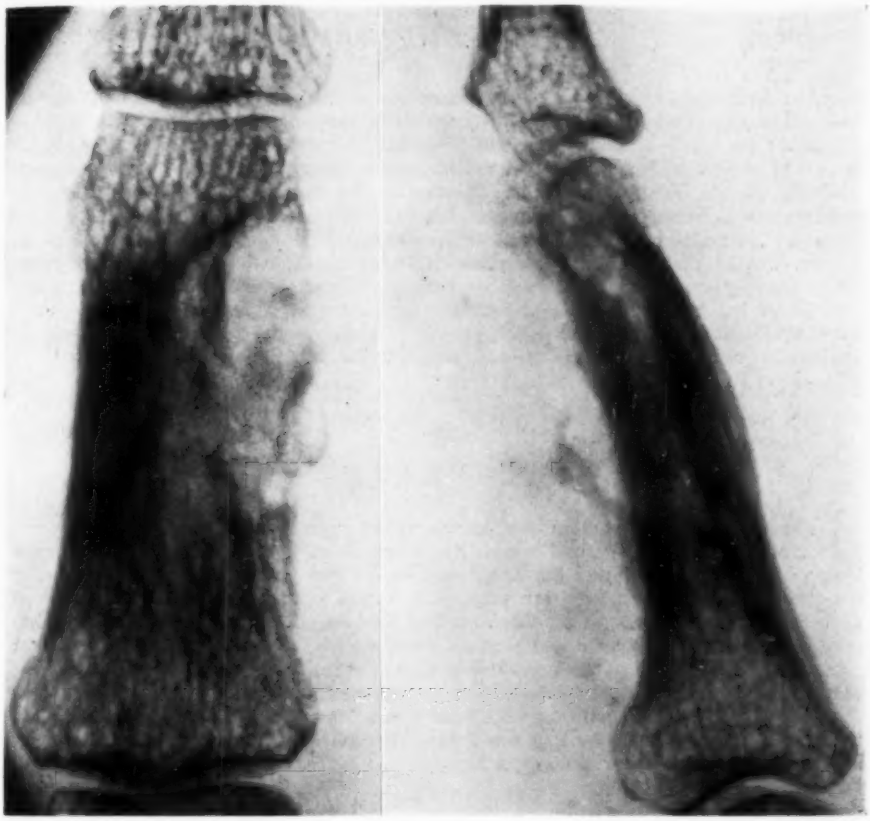

Abb. 8. Abb. 9.

Abb. 8. Der gleiche Finger wie Abb. 7, Feinstfokus 0.05 mm, Kodak-Diavidox-Film mit Sinegran-Fina-Folie, Abb.-Massstab 4 : 1, Originalgrösse.

Abb. 9. Seitliche Aufnahme von Abb. 8 unter gleichen Aufnahmebedingungen, Originalgrösse.

mit einer Unschärfe von 0.3 mm noch bis 11 fache Vergrösserungsaufnahmen erzielen. Auch die folienlose Vergrösserungsaufnahme ist der Normalfokusaufnahme mit Film überlegen, wenn die Fokusdimension unter 0.1 mm liegt. Man wird beim Feinstfokus aber stets eine Folie anwenden, um die Belichtungszeit herabzusetzen und um zu starken Vergrösserungen zu kommen.

Es ist von Vorteil, mit Feinstfokusröntgenröhren unter 0.3 mm zu arbeiten.

ZUSAMMENFASSUNG

Die förderliche radiologische Vergrösserung ändert sich je nach Kombination von Fokusdimension und Film- bzw. Folienunschärfe. Ihre Grenze liegt bei dem 0.3 mm Feinfokus bei einem Abbildungsmassstab von 2 : 1. Demgegenüber ermöglicht der regelbare 0.03 mm Feinstfokus mit Feinkornfolie von einer Unschärfe von 0.3 mm noch eine 11-fache direkte Vergrösserung ohne Minderung der Bildqualität. Eine direkte Vergrösserungsaufnahme ohne Folie ist auch bei Fokusdimensionen unter 0.1 mm, obgleich diese der Normalfokusaufnahme und der des 0.3 mm Feinfokus überlegen ist, nicht am Platze. Um zu kürzeren Belichtungszeiten zu kommen und weil die direkte radiologische Vergrösserung ausgenutzt werden soll, wird stets mit Folien gearbeitet. Die Detailerkennbarkeit ist bei Aufnahmen mit Fokusdimensionen unter 0.3 mm gegenüber dem Normalfokus und dem 0.3 mm Feinfokus erhöht. Die Ausdehnung des Objektdetails ist wie die förderliche radiologische Vergrösserung eine Funktion der Fokusdimension und der Film- bzw. Folienunschärfe.

SUMMARY

The effective radiographic magnification varies with the focal size of the tube and the unsharpness of the film and screen. For a fine focus of 0.3 mm it lies at an image scale of 2 : 1. With an adjustable 0.03 mm ultrafine focus and a fine-grained screen of 0.3 mm unsharpness it is, however, possible to obtain a further direct magnification of 11 times without diminution of image quality. It does not appear advisable to undertake direct magnification without screens, even with focal dimensions below 0.1 mm, although this is superior to those obtainable with a normal focus and a 0.3 mm fine focus. Screens are always employed for direct radiographic magnification in order that exposures shall be short. Detail is increased with focal dimensions below 0.3 mm as compared to the normal focus and the 0.3 mm fine focus. The amount of object detail is, however, like the radiographic magnification, a function of the focal size and the unsharpness of the film and screen.

RÉSUMÉ

L'agrandissement radiographique utile varie suivant les dimensions du foyer du tube et le grain du film et de l'écran. Pour un foyer fin de 0.3 mm il est de 2 : 1. Avec un foyer réglable ultra-fin de 0.03 et un écran à grain fin de flou 0.3 mm il est possible d'obtenir un agrandissement direct plus important de 11 fois sans diminution de la qualité de l'image. Il ne paraît pas indiqué de faire un agrandissement direct sans écrans, même avec un foyer de dimension inférieure à 0.1 mm, bien que les résultats soient meilleurs qu'avec un foyer normal ou avec un foyer fin de 0.3 mm. On emploie toujours des écrans pour l'agrandissement direct, pour avoir des temps de pose courts. Les foyers de dimensions inférieures à 0.3 mm donnent plus de détails que les foyers normaux et les foyers fins de 0.3 mm. La quantité de détails est cependant fonction, comme l'agrandissement radiographique, des dimensions du foyer et du flou du film et de l'écran.

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BOOK REVIEWS

ATLAS POSTMORTALER ANGIOGRAMME. Von J. Schoenmackers und H. Vieten. 203 Seiten, 145 Abb. Georg Thieme, Stuttgart 1954. DM 51: 30.

Pathologic changes of blood vessels play an important part in many diseases. Angiography is a useful and informative means of studying the macroscopic, and with special methods, even the microscopic pathology of vessels, especially after death. The proper injection pressure and a suitable contrast medium have to be chosen according to the organ and size of the vessels to be examined. The findings on dissection and subsequent histologic examination may be correlated to the roentgenologic appearance of the vessels and the angiographic picture of the disease established. By this means the value of intravital angiography may be assessed.

The co-operation of a pathologist and a roentgenologist ought to produce good results in this field. SCHOENMACKERS and VIETEN have made many excellent postmortal angiograms and these are beautifully reproduced. The pulmonary arteries and veins, the vessels of the heart, brain, kidneys and trunk, as well as the portal vein, are shown in normal and pathologic cases. A short clinical and pathologic survey is given in every instance. No methodical arrangement of the angiographic findings has, however, been attempted and consequently surprisingly little information can be obtained on the diagnostic value of the postmortal angiogram. The authors point out that conclusions regarding the intravital appearance of vessels should be drawn only with great care. They themselves do not, however, follow this rule. The width of veins depends, inter alia, on the injection pressure and the amount of contrast medium introduced. The demonstration of postmortal venous dilatation is, therefore, of little value if it cannot be correlated to conditions prior to death.

A case in which the contrast medium has not penetrated into all parts of the vessels is shown as being typical of atherosclerosis. The description of vascular changes in a given disease seems often to be based upon a single case or upon one or two cases. It is not clear if these appearances are characteristic of the pathologic condition and hardly any information is afforded concerning the mechanism of the changes described. The material is treated in a purely descriptive and haphazard manner.

The significance of this work is that it draws attention to the great possibilities of postmortal angiography for future research.

Åke Lindbom.

BASES DE L'INTERPRÉTATION RADIOLOGIQUE. RADIOGÉOMÉTRIE. Par Manoel de Abreus. 2 volumes. Texte: 214 pages. Iconographie: 312 pages. 683 figures, 82 planches. Masson & Cie., Paris 1954. Prix pour les deux volumes: 5,000 frs (brochés), 6,200 frs (cartonnés).

The work under review was published by the University of Rio de Janeiro in August 1951 in French. It is divided into two volumes consisting of a textbook of about 210 pages and a 'figure-supplement' of more than 80 roentgenograms (most of them of comparatively high quality) and nearly 700 schematic figures, all with explanatory text.

In the beginning of the book the author discusses the radiographic principles of geometric figures bounded by flat or variously curved surfaces by which the direction of the rays in relation to the different planes and their boundaries forms a real and constantly recurrent variable.

A special chapter is devoted to the different kinds of methods of tomography. In the one which follows, the conception of contrast and sharpness as well as the limits of discernibility are discussed in various connections.

The first four chapters form Part I, 'Théorie de la radiogéométrie', the other five being combined into a Part II which is called 'Démonstration pratique de la radiogéométrie'. In the former, the author proceeds mainly from certain simple geometric figures and their representation in different radiographic projections. In the second part he starts from certain organs and parts of organs and, in many cases, arrives directly at the principles of their reproduction by schematic figures. Perhaps more frequently, however, he tries as far as possible to simplify the details of the organ until he reaches some well-known or common geometric figure, the formation of which is easily explained. Particularly in the case of the lungs, this simplification has been carried out to such a degree that one often feels transported into the realms of cubist art.

The schematic figures are as elegant and skilful as they are broadly executed. Here and there, one admires the advanced simplification, within the limits of which nothing essential is missing.

As far as is known to the reviewer, this work is the first serious attempt to produce a comprehensive radiogeometry. That such a work should be complete or that future and larger works of the same nature should follow the same lines, naturally cannot be expected. Much of DE ABREUS' work will, however, certainly remain in its present form, certain parts being based, for example, upon accepted and classical geometry.

Should one feel inclined to point to certain details which are missing, and which, maybe, constitute a different outlook upon radiogeometry between the Latin countries and our own, mention may be made of the relative unimportance placed by the author upon the size of the focus (in practical work he mostly considers parallel beams) and upon a well-defined mathematical conception of the dissolution of detail, as well as upon the significance of simultaneous contrast in the subjective appreciation of contour.

Arne Frantzell.

RÖNTGENDIAGNOSTIK DES SCHÄDELS. Von W. Loepp und R. Lorenz. 579 Seiten, 613 Abb., Georg Thieme Verlag, Stuttgart 1954. DM 97: —.

This comprehensive textbook presents in detail the changes in various disease processes and malformations of the skull as shown by conventional radiography. Brief as well as more lengthy descriptions of the normal anatomy and the embryologic development of the various parts of the skull are also included and this, in my opinion, is of great value. The various parts of the skull (the vault, base, sella turcica, orbit, petrous bone, sinuses, as well as the maxilla and mandible with the teeth) are dealt with separately. This in a way makes the matter more readable but necessitates on the other hand a good deal of repetition. Changes caused by increased intracranial pressure are, however, with the exception of those occurring in the region of the sella turcica, brought together in a special chapter. Alterations in the appearances of the sella turcica are called 'die hydrocephale Drucksella', an unsuitable name, I feel, giving as it does the false impression that they are always secondary to hydrocephalus. Furthermore, it is stated in the text that pressure changes may be found even without hydrocephalus. On the whole, the changes in the sella turcica are not really adequately presented. Intracranial calcifications are dealt with in a special chapter, and various projections recommended by the authors are

briefly mentioned. To Swedish radiologists, at any rate, it appears rather remarkable that many of these projections are obtained by turning the patient's head instead of angling the tube; this latter method, if a Lysholm table is used, allows more exact projections to be obtained. There are several things in the book, which in my opinion are incompletely, or even wrongly described. A few examples may be given. The term 'platybasia' is used for a condition, which as far as can be judged from the brief description, should be basilar impression. This is said to be connected with assimilation of the atlas, which is often not the case. The lesion, which is usually referred to as a chronic subdural haematoma, is called an intradural haematoma without any mention being made of the generally accepted conception as to its nature. It may be that the authors are justified in employing this new term. It must, however, be somewhat confusing to the many readers who still consider such a haematoma to be subdural and may not even have heard of this new labelling.

Some of the illustrations are of fairly high quality, others less so. The majority were not produced by the authors themselves. According to the preface, the explanation for this lies in the fact that LOEPP lost his material of films during the war and collected a new one from colleagues all over Germany. His perseverance is certainly much to be admired, although, as a consequence of this method, the illustrations are not entirely uniform. Some of the changes illustrated are not as characteristic as they should be in a textbook. This is especially unfortunate in the many cases in which no verification is mentioned in the text. But even if the book has to be read with a certain criticism, it certainly has much to its credit.

Radiologists, especially those interested in skull radiography, should be greatly indebted to both authors: To LOEPP, who unfortunately died before his, in many ways, admirable work was finished, and to LORENZ for his readiness in engaging himself in the difficult task of completing it.

I. Wickbom.